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Eastern Brown Snake (*Pseudonaja textilis*) constricting and ingesting a Pygmy Bluetongue (*Tiliqua adelaidensis*). (Photo: A. Fenner). See article on p. 20.

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PREDATION BY A MYALL SNAKE (*SUTA SUTA*) ON A ROAD-KILLED LIZARD

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During a Queensland Parks and Wildlife Service survey of Astrebla National Park, from 11–16 May 2004, an adult Myall Snake (*Suta suta*) was observed consuming a road-killed Earless Dragon (*Tympanocryptis* sp.). This is the first record of *S. suta* feeding on carrion, and is also of interest due to the low temperatures at which the snake was active and feeding.

A *Suta suta* was observed while driving at about 2130 hrs at night on a narrow dirt road. It was identified without being handled, and was left where it was without being disturbed. The ground cover at this site consisted of sparse dry forbs on ash soils with deep cracks. On the return trip at about 0030 hrs, what is presumed to be the same snake was seen in the same area and was in the process of consuming a dead Earless Dragon. The temperature at the time of the second encounter was 17° C. The dead dragon was stiff, which leads us to believe that it was not freshly dead. As our vehicle was the only one in the park at this time, we assumed that we had run over the dragon, although as we had used the road daily for several days, it was not clear when it had been hit.

Although many hours were spent spotlighting each night of the survey, only two reptiles, both snakes, were seen active. The first, which escaped before it could be positively identified, was the size and colour of *S. suta*, and probably that species as well. Pitfall traps were open for four nights, but no nocturnal reptiles were trapped. The only reptiles col-

Figure 1. *Suta suta* consuming a road-killed *Tympanocryptis*.

lected in the pitfall traps were diurnally active Earless Dragons, *Tympanocryptis tetraporophora* and *T. cephalus*. The lack of nocturnal reptiles was attributed to the cool night temperatures at the time of the survey.

Shine (1988) recorded *S. suta* feeding on skinks, geckos, dragons, pygopods, typhlopids, squamate eggs, mammals and frogs. *Suta suta* has not been recorded active by day, and Shine suggested that the species actively hunted diurnal prey species in their resting sites at night, while ambush hunting is used by *Suta* to catch nocturnally active prey species. As *Tympanocryptis* are diurnal, and the individual being consumed was dead, the snake must have located it by active searching in this instance. The ability of *Suta* to hunt at low night temperatures when diurnal species are particularly inactive may further enhance its chances of catching resting diurnal lizards.

Although snakes are generally considered to feed mostly on prey caught while alive, *Aspidites melanocephalus, Pseudechis australis* and *Tropidonophis mairii* have been recorded feeding on road carrion in tropical Australia (Bedford, 1991a,b; Bedford & Griffiths, 1995). Bedford (1991a) reported *Tropidonophis* mairii in the Northern Territory actively searching for dead frogs. However the other reports, like the present observation, appear to involve chance encounters with carrion.

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PREDATION ON THE CANE TOAD *RHINELLA MARINA* (AMPHIBIA: BUFONIDAE) BY THE COASTAL TAIPAN *OXYURANUS SCUTELLATUS* (SERPENTES: ELAPIDAE).

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INTRODUCTION

Since its initial introduction in 1935 the cane toad *Rhinella marina* has spread across much of Northern Australia. Despite its long time residence in Australia only a few animals, mostly birds and mammals have been recorded to successfully prey on *R. marina*. These include Pied Currawongs *Strepera graculina* (Bekker, 1985), Torresian Crows *Corvus orru* (Donato & Potts, 2004), Black Kites *Milvus migrans* (Mitchell, 1995; Beckmann & Shine, 2010), Whistling Kites *Haliastur sphenurus* (Beckmann & Shine, 2010), Cattle Egrets *Bubulcus ibis* (McKillan, 1984), Black Rats *Rattus rattus* (Fitzgerald, 1990) and Water Rats *Hydromys chrysogaster* (Cassells, 1966). Reptiles on the other hand have experienced large scale declines in some species (Doody *et al.*, 2008; Phillips *et al.*, 2009) and only the following have been recorded to suc-

Figure 1. Apparent road killed Coastal Taipan (*Oxyuranus scutellatus*) with prey bolus from Channel Point Road, Rakula, Northern Territory.

cessfully prey on *R. marina* in the wild: *Crocodylus porosus* (Covacevich & Archer, 1975), *Myuchelys latisternum* (Hamley & Georges, 1985) and *Tropidonophis mairii* (Lyon, 1973; Shine, 1991; Llewellyn, 2008).

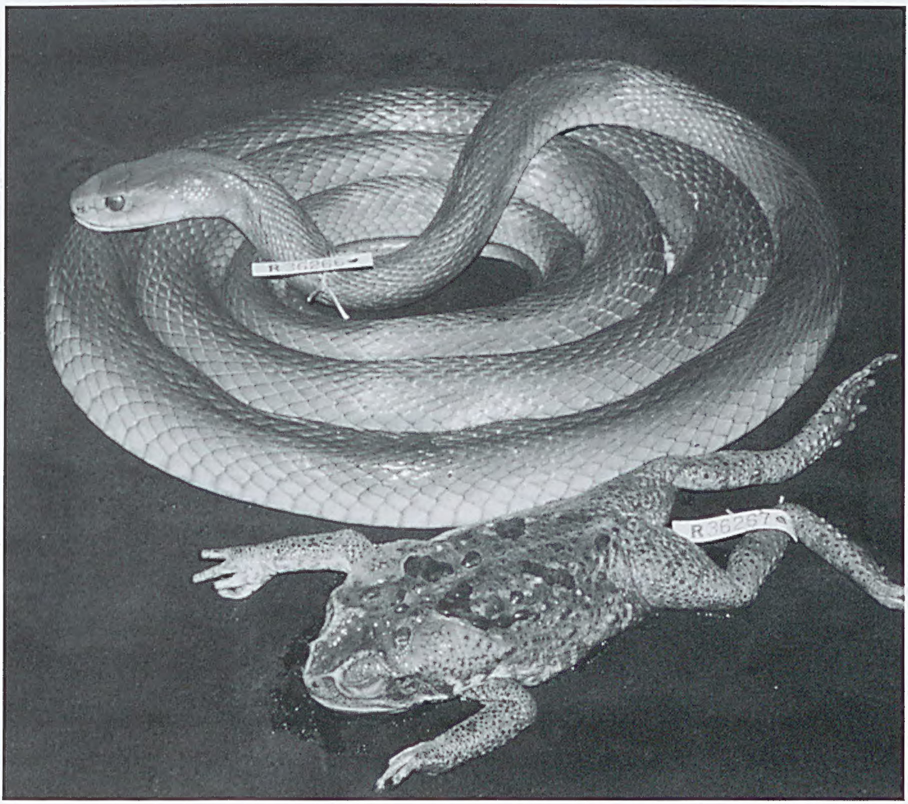
OBSERVATION

At 1745 hours on 6 May 2010 one of us (RC) collected an apparent road-killed Taipan *Oxyuranus scutellatus* (Figure 1) near the turnoff to Labelle Station on Channel Point Road, Rakula, Northern Territory (13°06'12"S 130°30'14"E). On dissection (Figure 2), the snake proved to be an adult male (1490 mm snout-vent length, total length 1773 mm, mass 540 g; convoluted efferent ducts with large, 7 mm wide, opaque testes indicating sperm production) that had ingested an immature female *Rhinella marina* (93 mm snout-ilium length, mass 90 g). The snake appeared in good health apart from signs of trauma to the neck and coagulated blood present in the mouth. The snake and toad were subsequently deposited at the Museum and Art Gallery of the Northern Territory (NTM R.36266-67 respectively).

DISCUSSION

Oxyuranus scutellatus has not previously been recorded to prey upon *R. marina*. A study of

Figure 2. Coastal Taipan (*Oxyuranus scutellatus*) with Cane Toad (*Rhinella marina*) from Channel Point Road, Rakula, Northern Territory. Photograph by Thomas Parkin.



museum specimens (Shine & Covacevich, 1983) showed that this species has a diet consisting of 94% mammals which was congruent with earlier anecdotal dietary observations. Shine and Covacevich's (1983) dataset consisted mostly of specimens from Queensland, raising the possibility that diet may be different in the Northern Territory. However the small numbers of specimens examined from the Northern Territory have also been found to prey mostly upon mammalian prey (D. Trembath, unpub. data). Shine and Covacevich (1983) further suggested that this species may not have been impacted as much as other large sympatric amphibian-eating elapids from the introduction of *R. marina*.

The snake we found may have died from lethal toxic ingestion from eating the *R. marina*, or may have successfully eaten it and then was run over by a car. We discuss both possibilities here. If the snake died from lethal toxic ingestion we can add *O. scutellatus* to the list of species of predators that are killed by *R. marina* (reviewed by Shine, 2010). If the snake was killed by a car and would have survived the toad, then *O. scutellatus* may have some resistance to toad toxins. Covacevich and Couper (1992) similarly reported the finding of a freshly dead *Morelia spilota* that contained a large ingested *R. marina*, suggesting that some species may be able to consume *R. marina* but succumb to the effects of their toxins later. Fearn (2003) reported finding a freshly dead adult *Pseudechis porphyriacus* that had consumed two subadult *R. marina*. He cautiously suggested that *P. porphyriacus* may be able to ingest metamorph *R. marina* in the Tully area, but would die if ingesting larger specimens. Interestingly, *T. mairii*, which is known to consume cane toads regularly, has also been shown to sometimes die when ingesting toads (Ingram & Covacevich, 1990; Shine, 1991).

Oxyuranus scutellatus employs a strike and release response when dealing with prey, presumably to counter the risks of dealing with large rodents (Shine & Covacevich, 1983). This method of killing prey may enable *O. scutellatus* to kill *R. marina* without being killed by ingesting them. Phillips *et al.* (2007) showed that *Acanthophis* sp. at Fogg Dam prey upon the highly toxic frog *Litoria dahlii* using a specific response to this prey item. They found that when *Acanthophis* sp. encountered a *L. dahlii* in the lab, they would bite and then release it, followed by a period of waiting in which the toxins present in the *L. dahlii* would degrade. After this waiting time, *Acanthophis* sp. can consume a prey item which is usually toxic if ingested immediately.

In ending we cannot conclusively determine what may have killed the *O. scutellatus*, however this observation does raise the point that assessing snakes based on percentage of frogs in diet (Phillips *et al.*, 2003) may not be able to predict which species are impacted. In order to effectively study the impacts of *R. marina*, intensive field studies would need to be implemented on all species of tropical snakes regardless of dietary preference.

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LOW ELEVATION RECORDS FOR THE POUCHED FROG *ASSA DARLINGTONI* IN BYRON SHIRE, NEW SOUTH WALES.

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INTRODUCTION

The Pouched Frog *Assa darlingtoni* is well known for its distinctive reproductive biology where male frogs carry tadpoles in small pouches on either side of the body (Anstis, 2002). It is a threatened species listed as Vulnerable in New South Wales (OEH, 2012).

Pouched Frogs are reported to occur in rainforest in mountainous areas of the NSW/Qld Border area (Anstis, 2002; Cogger, 1996; NPWS, 2002; Tyler, 1994). NPWS (2002) noted the species occurred "...mostly above 800m".

However, although a survey of the Murwillumbah Forestry Management Area recorded Pouched Frogs at a number of intermediate (200-500 m AHD) and low (0-200 m AHD) elevation sites in Lismore, Byron and Tweed Shires (CSIRO, 1995), and there are recent records from similar elevations in this area in the NPWS Atlas of NSW Wildlife (OEH, 2010), these occurrences do not appear to be recognised in the published literature.

This note collates low elevation records of Pouched Frogs from eight locations in Byron Shire in New South Wales, including its occurrence in forest dominated by exotic plant species and recent occupation of regrowth forest.

METHODS

Pouched Frogs were recorded on the basis of their distinctive call in the course of ecological surveys and travel at six of the eight locations. Of the remaining two, the Left Bank Road (Mullumbimby) location is the first author's place of residence, where Pouched Frogs have been calling irregularly since December 2011. The Snow's Gully (Upper Cooper's Creek) location is where the second author resided between 1981 and 1997 and where Pouched Frogs colonised an area of rainforest regeneration, being recorded by calls from 1992 onwards, approximately eight years after regeneration commenced.

RESULTS

Table 1 details the locations and dates of Pouched Frog records, their elevations and other site attributes. The locations were between 5-300 m and mostly within 100 m of permanent creeks, between 58 and 210 m elevation (AHD) and in moist areas where a substantial leaf litter layer had accumulated. Most locations were also characterised by the presence of rhyolite boulders eroded from nearby cliff lines. The condition of occupied habitat varied from young regenerating forest, heavily disturbed forest dominated by exotic plant species to relatively undisturbed mature forest. Where eucalypt species dominated the canopy there was also usually a well-developed rainforest understorey. The exotic Lantana (*Lantana camara*) was a common understorey species at disturbed locations, and at two heavily disturbed locations (Wilson's Creek Road, Wilson's Creek and Maori Creek, Durrumbul) the exotic Camphor Laurel (*Cinnamomum camphora*) dominated the canopy and Mistflower (*Ageratina riparia*) was an understorey dominant.

DISCUSSION

The records of Pouched Frogs documented in Table 1 demonstrate that the species occurs at substantially lower elevations in Byron Shire than reported in the literature. These records were collected opportunistically and it is expected that Pouched Frogs occur in suitable

Table 1. Low elevation records for Pouched Frogs *Assa darlingtoni* in Byron Shire, NSW. Asterisks indicate exotic plant species.

Location/Date	Lat/long	Elevation	Habitat
Snow's Gully, Upper Cooper's Creek, 1992-1997	28.59S 153.39E	140 m AHD	Young regenerating subtropical rainforest 30 m from mature subtropical rainforest, Lantana* understorey, rhyolite boulders on rhyolite and basalt with well-developed litter layer.
Wanganui Gorge, Upper Cooper's Creek, 30.iii.1996	28.60S 153.40E	140-160 m AHD	Disturbed sub-mature subtropical rainforest, Lantana* understorey, rhyolite boulders on rhyolite and basalt with well-developed litter layer.
Minyon Falls Track, Nightcap SRA, 1, 26.iii. 1996; 30.iv.1996; 11.v.1996; 20.ix.2000	28.62S 153.39E	140-210 m AHD	Mature subtropical rainforest, Stream Lily (*Helmholtzia glaberrima*) understorey, rhyolite boulders on rhyolite and basalt with well-developed litter layer.
Cedar Road, Wilson's Creek,xi.2005	28.57S 153.44E	~160 m AHD	Tall closed eucalypt forest, Grey Ironbark (*Eucalyptus siderophloia*), Blackbutt (*E. pilularis*), Tallowwood (*E. microcorys*) and Lantana*.
Wilson's Creek Road, Wilson's Creek, various sites including near Wilson's Creek Primary School, 2004-5	28.57S 153.42E	~160 m AHD	Roadside forest, Camphor Laurel*, Mistflower*.
Maori Creek, Durrumbul, 30.v.2009	28.53S 153.43E	110 m AHD	Heavily disturbed subtropical rainforest dominated by Camphor Laurel* with Mistflower* and Crofton Weed* (*Ageratina adenophora*) ground cover, some rhyolite boulders on rhyolite and basalt, well-developed litter layer.
Skyline Road, Upper Main Arm, 3-7.vi.2011	28.50S 153.38E	150-190 m AHD	40-50 year old closed eucalypt forest with well-developed subtropical rainforest understorey, Flooded Gum (*E. grandis*), Blackbutt, Small-fruited Grey Gum (*E. propinqua*), Pink Bloodwood (*Corymbia intermedia*), some rhyolite bounders on rhyolite and basalt, well-developed litter layer.
Left Bank Road, Mullumbimby Creek, xii.2011	28.55S 153.43E	58 m AHD	Regrowth lowland rainforest/garden, Red Kamala (*Mallotus philippensis*), Macaranga (*Macaraga tanarius*), Firewheel Tree (*Stenocarpus sinuatus*) & Fishtail Palm (*Caryota mitis*)*; rhyolite boulders & leaflitter.

habitat at low elevations at many other locations within the Shire. Low and mid elevation records collected by the CSIRO in adjoining Lismore and Tweed Shires in 1995 suggest that the species' range typically extends to low elevations throughout its distribution in far north east NSW.

The occurrence of the Pouched Frog in highly disturbed and regrowth forests dominated by the exotic Camphor Laurel, and in litter under a Lantana and Mistflower ground cover indicates that the species can opportunistically occupy these vegetation types, particularly when they occur in close proximity to relatively undisturbed native vegetation.

The Mullumbimby Creek records demonstrate the recent colonisation of 30 year old regrowth forest in an area where the species had not previously been detected, and the Snow's Gully records indicate colonisation of even younger stands. Consecutive wet years, maintaining a stable moisture regime combined with forest regrowth producing an accumulation of leaf litter appears to have facilitated the species' expansion into these low elevation areas.

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ACCOUNT OF A GREATER BAR-SIDED SKINK *EULAMPRUS TENUIS* TRAPPED IN A NARROW CREVICE OPENING

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INTRODUCTION

The Greater Bar-sided Skink *Eulamprus tenuis* (Figure 1) is a common insectivorous lizard that occurs in Sydney. The species is saxicolous and arboreal, found in woodland and forested areas on the east coast of Australia (Greer, 2002; Rankin, 1973). The Bar-sided Skink is not frequently seen because of its crepuscular habits and preference for shade. Basking often occurs close to retreat sites such as rock crevices, hollow logs and cracks in trees (Swan *et al.*, 2004).

OBSERVATION

On 8 July 2012, while bushwalking in Georges River National Park (33.97°S 151.01°E), south of Sydney, I observed a Bar-sided Skink becoming wedged at the head and neck region in a narrow part of a sandstone crevice (Figure 2). The incident occurred in dry sclerophyll forest on a steep hillside dominated by sandstone structures. The crevice was of relatively even width at first glance; however upon re-examination post-incident, the roof possessed rough protruding grains of sandstone, most likely from erosion. The trapped lizard was an adult, approximately 6 cm SVL.

I observed the lizard basking next to the crevice before trying to retreat, presumably disturbed by my approach. The head and neck became firmly lodged between the roof and base of the crevice as the lizard pressed

Figure 1. A Greater Bar-sided Skink *Eulamprus tenuis*.

Figure 2. Head and neck of lizard firmly lodged between the roof and base of the crevice.

itself into the resulting position, rotating the head from side to side to penetrate further. The body and tail was left completely exposed (Figure 3). I touched the lizard around the hind limbs to determine that the lizard was actually caught, as opposed to choosing to remain stationary. The time of the incident was 15:56 hours, referenced from a digital image recording. At the time, there seemed a possibility that the lizard was tensing up parts of the neck against the crevice roof in a defensive response of my presence; hence the lizard would relax its body upon my departure and escape by its own means. Initially I chose not to engage in action that may constitute interference.

I returned at 16:33 hours (more than half an hour later) and found the lizard in the identical position. Presuming that the lizard was highly unlikely to free itself and would certainly succumb to inevitable predation or starvation otherwise, I aided its release. I gradually slid a fresh eucalypt leaf over the lizard, utilising temporary gaps between the lizard and the crevice roof created as the lizard rotated tension around different parts of its neck region. The leaf was wedged to shield the lizard's head and neck from the rough texture of the crevice roof. I grasped the lizard by the body and applied gentle tension away from the rock structure, freeing the lizard with relative ease.

The lizard, placed on a part of the sandstone structure where I initially observed it, showed obvious signs of weariness, i.e. heavy breathing. Apart from minor scratches to the scales on the head, no serious injuries were sustained (Figure 4). The lizard returned to its crevice without difficulty after a short recovery. Under torchlight, I observed another Greater

Figure 3. The lizard in a vulnerable position with the body and tail completely exposed.

Bar-sided Skink and a Broad-tailed Gecko *Phyllurus platurus* deeper in the same crevice. From this, I gather that the particular crevice is commonly used by saxicolous lizards.

REMARKS

Although the incident occurred when the lizard attempted to retreat in response to my approach, I consider the action of it becoming caught between the roof and floor of the crevice a natural occurrence. The same situation may have occurred if a predator such as a carnivorous bird or monitor lizard had been the cause of the disturbance. The incident described here raises questions as to the frequency and/or likelihood of saxicolous lizards becoming trapped in their natural retreat sites. In the past, it would be presumed that saxicolous taxa move fluidly in their natural surroundings and would probably never become trapped in a position as described here. This observation is an example of a saxicolous species misjudging the size of a crevice opening and taking up a position that could result in death.

Although scale loss did not occur in this incident, scincid lizards can be quite resilient towards open abrasions. In the past, I have observed free-living White's Skinks *Liopholis whitii* and Eastern Blue-tongued Skinks *Tiliqua scincoides* persisting in the wild despite missing scales. In addition, head wounds are frequently sustained in male Broad-headed Skinks *Eumeces laticeps* during intraspecific fighting (Cooper & Vitt, 1987).

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I thank Dr Brad Law for reviewing the original manuscript and providing useful comments.

Figure 4. Minor scratching on the head post-incident.

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NOTES ON THE TAN-BACKED ROCK-SKINK *LIOPHOLIS MONTANA* IN KOSCIUSZKO NATIONAL PARK, NEW SOUTH WALES

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The Tan-backed Rock-skink *Liopholis montana* is a recently described and little-known species with a limited distribution in the mountain areas of far southern New South Wales, the ACT and north-eastern Victoria (Donnellan *et al.*, 2002; Swan *et al.*, 2004; Chapple *et al.*, 2005). There are few documented records of this lizard within New South Wales. For example, Donnellan *et al.* (2002) listed a single specimen collected at Rennix Gap in Kosciuszko National Park in 1991 and a number of records from adjacent parts of the ACT including Mt Ginini and Mt Scabby. It has a seemingly discontinuous patchy distribution and is rare throughout its range (Donnellan *et al.*, 2002). Due to the paucity of information available on this species in New South Wales, this note summarises records made from three locations while conducting fauna surveys in areas of major disturbances in Kosciuszko National Park between January 2011 and March 2014. These disturbance areas, such as quarries and spoil dumps, were associated with works conducted as part of the Snowy Mountains Hydro-electric Scheme in the 1950s and 1960s.

OBSERVATIONS

Location 1

Happy Jacks Road, south east of Cabramurra (36°00'S 148°27'E) at an altitude of 1300 m on a north-easterly slope approximately 120 m upslope of Happy Jacks Creek. A single individual was captured in an Elliott A trap baited with walnut pieces set in a culvert under the road on 26 January 2011. The habitat comprised scattered Snow Gums *Eucalyptus pauciflora* and Spinning Gums *E. perriniana*, with patches of shrubs including Royal Grevillea *Grevillea victoriae*, *Cassinia* species, Elderberry Panax *Polyscias sambucifolius* and Native Raspberry *Rubus parvifolius*. No other individuals were seen or captured in 100 trap days in this location during this period or in 8205 trap nights conducted during 10 visits to this section of the Happy Jacks Valley between November 2010 and November 2013 while undertaking field work on the Mountain Pygmy-possum *Burramys parvus*. Sympatric skink species recorded were the Black Rock Skink *Egernia saxatilis*, Pale-flecked Garden Sun-Skink *Lampropholis guichenoti*, Tussock Cool-skink *Pseudemoia entrecasteauxii*, Grassland Cool-skink *Pseudemoia pagenstecheri* and Blotched Blue-tongued Lizard *Tiliqua nigrolutea*.

Location 2

Tantangara Dam Quarry, north west of Adaminaby (35°48'S 148°38'E) at an altitude of 1230 m in an area of cold air drainage associated with Kellys Plain Creek. Ten individuals were observed active in screes at the base of the quarry and in low rock piles adjacent to nearby Kellys Plain Creek, including one in an old campfire rock pile between 12 and 14 November 2011. The habitat consisted of scattered Snow Gums and Black Sallee *E. stellulata*, with the few shrubs present dominated by Alpine Wattle *Acacia alpina* and Alpine Shaggy-pea *Podolobium alpestre*. No individuals were captured in 225 trap days using Elliott A traps baited with walnuts in this location. Sympatric skink species recorded were *L. guichenoti, P. pagenstecheri* and *T. nigrolutea*.

Location 3

Geehi Dam Quarry, south east of Khancoban (36°18'S 148°18'E) at an altitude of 1140 to 1180 m in an area of cold air drainage associated with Middle Creek. Two individuals were observed and a single individual was captured in an Elliott A trap baited with

walnut pieces set on an upper bench of the quarry between 8 and 10 January 2012. Habitat comprised scattered Alpine Ash *E. delegatensis* and Mountain Gum *E. dalrympleana* saplings, with sparse shrubs of various species including Bitter Bush *Daviesia latifolia*, Sticky Everlasting *Ozothamnus thyrsoideus*, Geebung *Persoonia confertiflora*, Royal Grevillea *Grevillea victoriae*, Leafy Bossiaea *Bossiaea foliosa*, *Rubus parvifolius* and Groundsel Fireweed *Senecio linearifolius*. No other individuals were captured in 360 trap days at four sites within this location. Sympatric skink species recorded were the Eastern Three-lined Skink *Acritoscincus duperreyi*, Highland Water-skink *Eulamprus tympanum*, *L. guichenoti* and *P. entrecasteauxii*.

DISCUSSION

The three locations were all below the 1400 m lower altitudinal limit outlined by Donnellan *et al.* (2002) for the northern parts of the species' range. None of the sites were dominated by granite outcrops as described by Swan *et al.* (2004); instead the rock types were quartzites and greywackes (Happy Jacks Road), dacite (Tantangara Dam Quarry) and gneiss and diorite (Geehi Dam Quarry) (CH2M Hill, 2000a-c). Donnellan *et al.* (2002) noted that the species occurs in a variety of habitats but prefers open areas, such as the rain-shadowed sides of ridges with outcropping boulders or slabs or in rock screes, where it occurs in colonies and shelters in deep burrow networks constructed

Figure 1. *Liopholis montana* captured in an Elliott A trap, Geehi Dam Quarry, Kosciuszko National Park.

beneath rocks. All of the present sites had been burnt during the 2003 wildfire and occurred in open situations with few trees and shrubs as a result of disturbance from the past Snowy Hydro activities, with numerous rocks and some scree habitat present. These sites had a sparse ground vegetation, which was dominated by native *Poa* species and a variety of exotic grass and weed species. One site on the crest of Geehi Dam Quarry was on an unstable slope of deep soil with little rock present and the individual was observed on a number of occasions sunning itself at the entrance of a burrow that was not located underneath rock or other debris.

The location of this species in only three of the 21 major disturbance sites surveyed by the author within Kosciuszko National Park between 2006 and 2014 may either be as a result of the species being difficult to locate using conventional survey techniques including the deployment of Elliott traps or due to the species being uncommon and patchily distributed. The latter suggestion supports the conclusion of Donnellan *et al.* (2002) that it is rare and localised within its distribution. Currently the species is not listed as threatened under state or federal legislation although it is currently listed as data deficient in Victoria (Department of Sustainability and Environment, 2013) and it has been suggested that the species be considered for listing in that state (Clemann, 2002). Given it is poorly understood and there are few documented locality records it is important that any sightings or captures of this lizard be entered into state-based wildlife atlases to develop a better understanding of the species' distribution and abundance.

ACKNOWLEDGMENTS

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AN OBSERVATION OF RAISED TAIL WAG BEHAVIOUR IN A SKINK

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Many reptiles use stereotyped antipredator displays, but most of the available information comes from observations of captive animals. In this note, we report a case of a distinctive antipredator tactic being employed by a free-ranging lizard. At 0840 hr Eastern Daylight Savings Time on 19 January 2007, in cool (approximately 20°C) but sunny weather, raised tail-wagging behaviour was observed in a Garden Skink (*Lampropholis guichenoti*). The observer (ME) was walking along a concrete pathway in the University of Sydney Campus (33°53'S 151°11'E), and startled an adult Garden Skink basking in the morning sun. The skink immediately sprinted away from the observer for about one metre, followed by a sudden halt and a 180° turn-around so that the lizard was facing the observer. The skink then raised the distal half of its tail perpendicular to the ground, and rapidly undulated the upright section in a "wagging" behaviour. This display lasted a couple of seconds before the lizard escaped into the vegetation lining the pathway.

We have also observed this behaviour in the laboratory many times during the course of our research on the Three-lined Alpine Skink, *Bassiana duperreyi*, particularly during measurements of hatchling locomotor speed (Shine, 1995; Elphick & Shine, 1998). To measure locomotor performance in the lab, we placed a Three-lined Alpine Skink into a purpose-built racetrack, and encouraged it to run the one metre distance by creating a disturbance behind the lizard with an artist's paintbrush. Sometimes a lizard, before reaching the end of the track, would stop suddenly, turn around 180° and rapidly "wag" its upraised tail. The raised tail-wag behaviour (RTW) we see in our laboratory locomotor trials is exactly the same as reported here in *Lampropholis guichenoti* in the field.

The use of tail displays in lizards is a well-documented phenomenon. Carpenter and Ferguson (1977) listed 158 stereotyped behaviours in lizards, one of which was the "tail wave" where "the raised tail is moved laterally, back and forth, up and down, or forwards and backwards". However, their "tail wave" description doesn't correspond exactly to the raised tail-wag behaviour we observed (i.e., there was no mention of lizards stopping abruptly and then performing a 180° turn-around). Additionally, Carpenter and Ferguson (1977) posit that the "tail wave" behaviour occurs during or just preceding aggressive actions, whereas the RTW we see in our experimental lizards is almost undoubtedly an antipredator behaviour. Shine (1995) postulated that lizards employing this behavior are able to attract the predator's attention to the tail, which is autotomized when seized. The lizard can then elude the preoccupied predator by running back the way it came, under or beside the predator's body. Torr and Shine (1994) published a comprehensive ethogram for *Lampropholis guichenoti*, documenting 45 behaviours that included a "tail-lash" (side-to-side undulation of the tail) and a "tail twitch" (rapid vibration of the distal third of the tail). Again, as there was no mention of the "tail twitch" occurring in a lateral or vertical orientation, it is unclear whether the tail twitch is the same as the raised tail-wag behaviour we observed. Raised tail-wag behaviour has been seen not only in captive *B. duperreyi* (Shine, 1995; Elphick & Shine, 1998), but also in captive *Lampropholis guichenoti* (F. Qualls, pers. comm.) and *Eulamprus tympanum* hatchlings (P. Doughty, pers. comm.) during laboratory research. The Rainbow Skink, *Carlia jarnoldae*, also uses various tail displays (Langkilde *et al.*, 2005), possibly the same RTW as observed here, but again, the observation was made on captive animals.

Hence our observation may be the first published record of this behaviour in a free-ranging skink, to confirm that lizards exhibit this behaviour in the field as well as the laboratory. Further research to quantify the generality of such behaviours would be aided greatly by keen herpetologists publishing such records.

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ACCIDENTAL DISTURBANCE ALLOWS PYGMY BLUETONGUE LIZARDS (*TILIQUA ADELAIDENSIS*) TO SURVIVE PREDATION ATTEMPTS BY EASTERN BROWN SNAKES (*PSEUDONAJA TEXTILIS*)

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INTRODUCTION

The Pygmy Bluetongue Lizard, *Tiliqua adelaidensis*, is a small (SVL 95 mm), endangered scincid lizard found in remnant fragments of native grasslands in the mid north of South Australia (Armstrong *et al.*, 1993; Hutchinson *et al.*, 1994). Lizards occupy burrows constructed by lycosid and mygalomorph spiders which they use for both shelter and as vantage points for ambushing passing prey (Fenner *et al.*, 2007; Milne *et al.*, 2003). Lizards are probably most vulnerable to predation while moving around on the surface (Fenner *et al.*, 2008a), however snakes have been observed to prey on lizards that are basking at their burrow entrance (Fenner *et al.*, 2008b). When an occupied burrow is inspected with an optic fibre scope, lizards will often tilt their head down against the burrow wall, exposing only the hard armoured top of the head. It has previously been suggested that this behaviour is to prevent a predator, like a snake, that is above the lizard in the burrow, from grasping, dislodging or attacking the occupant within the burrow (Fenner *et al.*, 2008b; Hutchinson *et al.*, 1994). Known predators of the Pygmy Bluetongue Lizard included Brown Snakes (*Pseudonaja textilis*) and raptors, for example, Nankeen Kestrels (*Falco cenchroides*) (Armstrong & Reid, 1992; Fenner *et al.*, 2008a,b). Milne and Bull (2000) also reported foxes digging at known Pygmy Bluetongue burrows.

The Eastern Brown Snake, *Pseudonaja textilis*, is a large (up to 2 m), slender, fast moving elapid (Cogger, 2000). Brown Snakes are active, generalised predators of small vertebrates, such as House Mice, *Mus musculus*, but will also prey on reptiles and amphibians in less disturbed areas (Shine, 1977, 1989; Whitaker & Shine, 2003).

This paper reports on two Pygmy Bluetongue Lizards surviving after one of the authors (A.L.F.) accidentally disturbed two separate Eastern Brown Snake predation attempts. The observations took place in a semi-arid grassland near Burra (33°41'S 138°56'E), in the mid north of South Australia, previously described as Site 2 by Fenner and Bull (2007) and now known as the 'Tiliqua' property of the Nature Foundation of South Australia.

OBSERVATIONS

The first observation took place on 29 October 2013 at 0905 hrs. As I (A.L.F) approached a burrow known to be occupied by an adult male Pygmy Bluetongue Lizard, which was part of an unrelated experimental study, I noticed a Brown Snake (approximately 70 cm in length) holding onto the head of the lizard. The majority of the lizard's body (from the forelimbs down) remained in the burrow. Upon my approach, the snake released the lizard head and rapidly slithered away in the opposite direction from which I had come. The lizard, upon being released, rapidly descended into its burrow. I inspected the lizard burrow with an optic fibre scope at 0910 hrs and 0935 hrs, and on both occasions the lizard was at the bottom of its burrow, alive and alert (moving its eyes and reacting to the optic fibre scope). I continued to monitor the lizard over the next few hours and at 1020 hrs, 1100 hrs and 1230 hrs I observed the lizard basking at the burrow entrance with no apparent ill effects from the attack. At 1530 hrs the lizard was no longer basking at the surface, nor was it in its

Figure 1. Eastern Brown Snake (*Pseudonaja textilis*) ingesting an adult male Pygmy Bluetongue Lizard (*Tiliqua adelaidensis*) prior to regurgitation.

burrow. I made a thorough search in the vicinity of the burrow and did not find a dead body, so I assumed this lizard relocated to another burrow.

The second observation occurred the following day, 30 October 2013, at 0930 hrs, at the same population site and a few hundred metres away from the first observation. On this occasion I (A.L.F) was driving along a farm track and noticed a Brown Snake wrapped around and already ingesting a Pygmy Bluetongue Lizard (Figure 1). I stopped and got out of my car and slowly approached the snake intending to observe and photograph the feeding sequence. However, my presence unsettled the snake and it regurgitated the lizard that had been partially ingested, head first and up to the shoulders. The snake was around 60 cm long and once it had regurgitated the lizard, it rapidly slithered off the track and into a grass tussock. The lizard remained on the track, not moving, and with its mouth slightly agape and tongue partially out, although still breathing. I picked up the lizard, identified it as an adult male from its size and head shape, and noted that it was very lethargic and not struggling or moving. I rinsed off the fluids, which may have been snake saliva and/or venom, from the anterior end of the lizard, using bottled water I had with me. The only observable injuries were a few minor scratches to the top of the lizard head and lower jaw. I then placed the lizard in a calico bag, and kept the bag out of the sun in a caravan located at the field site, and monitored its progress, presuming it would die. I checked on the lizard every 30 mins until 1400 hrs and each time it was alive, although still very lethargic and not responsive to being touched or handled. At 1430 hrs I returned to the nearby house that we use as a base for field work, and placed the lizard in a 55 l terrarium, with a sand substrate and artificial burrow (a length of PVC pipe) and a 40 watt heat lamp. I placed the lizard into the artificial burrow and left it undisturbed until 0600 hrs on the following morning. It had survived the night, although it was still lethargic and unresponsive to being touched and handled. However, by 1700 hrs, the lizard had started moving around the terrarium and appeared more responsive to my presence and being handled. The lizard continued to become more responsive and started behaving similarly to other recently captured Pygmy Bluetongues over the following days. Three days after the attack, on 2 November 2013, it appeared to be fully recovered from the incident, and at the time of acceptance of this report, 26 March 2014, almost 5 months after the predation attempt, the lizard is still alive and well.

DISCUSSION

These two observations provide information on rarely observed predation events by eastern brown snakes on Pygmy Bluetongue Lizards. Whilst we cannot be sure that either lizard was envenomated by the snakes during the predation attempt, it would appear that at least the second lizard (Figure 1) showed signs of envenomation following the attack. These two observations suggest that Pygmy Bluetongue Lizards may either have some immunity to Brown Snake venom, or the delivery of the venom to the head region is not effective in killing the lizard, although it may help to subdue the lizard. It is also possible that Brown Snakes may not envenomate Pygmy Bluetongue Lizards, but instead rely on overpowering them during ingestion. It is worth mentioning that in both cases it is highly unlikely that the lizards would have survived the predation events had the snakes not been disturbed.

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NOTES ON REPRODUCTION OF THE STUMP-TOED GECKO, *GEHYRA MUTILATA* (GEKKONIDAE) FROM THE HAWAIIAN ISLANDS

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INTRODUCTION

Gehyra mutilata (Wiegmann, 1834) is widespread throughout the Indian and Pacific Oceans and Southeast Asia (Bauer & Henle, 1994; Rocha *et al.*, 2009). Much of this range, as well as populations established elsewhere, is due to human introductions via cargo shipments (Kraus, 2009). This species is thought to have reached Hawaii the same way, travelling with Polynesian settlers (McKeown, 1996; Kraus, 2009). *Gehyra mutilata* is oviparous, ranges widely throughout the Hawaiian Islands (McKeown, 1996), and is now typically found in non-edificarian situations (FK, pers. obs.), although it was apparently common enough in those circumstances prior to the introduction of *Hemidactylus frenatus* (c.f. Oliver & Shaw, 1953). Herein we provide the first histological information on the reproductive cycle of *G. mutilata* from Hawaii as part of ongoing studies on the reproduction of lizards from Oceania.

MATERIALS AND METHODS

A sample of 68 *G. mutilata* from Hawaii consisting of thirty-one adult males (mean SVL = 46.0 mm ± 2.5 SD, range = 41-51 mm), thirty-two females (mean SVL = 46.3 mm ± 3.6 SD, range = 39-53 mm), four subadults (mean SVL = 33.0 mm ± 1.4 SD, range = 31-34 mm), and one neonate (SVL = 20 mm), collected 1900 to 2008 was examined from the herpetology collections of the Bernice P. Bishop Museum (BPBM), Honolulu, Hawaii, USA, the Carnegie Museum of Natural History (CM), Pittsburgh, Pennsylvania, USA, and the Natural History Museum of Los Angeles County (LACM), Los Angeles, California, USA.

The left gonad was removed from each specimen and embedded in paraffin. Histological sections were cut at 5 μm and stained by Harris hematoxylin followed by eosin counterstain (Presnell & Schreibman, 1997). Enlarged follicles > 3 mm length and oviductal eggs were counted and were not histologically examined. An unpaired t-test was used to compare male and female body sizes using Instat (vers. 3.0b, Graphpad Software, San Diego, California).

RESULTS

There was no significant size difference in SVL between our samples of male and female *G. mutilata* (unpaired t-test, $t = 0.36$, $df = 61$, $P = 0.72$). The only stage present in the testicular cycle of males of 41 mm SVL or greater was spermiogenesis (= sperm formation) in which the lumina of the seminiferous tubules were lined by groups of sperm or groups of metamorphosing spermatids. The epididymides were not sectioned but were grossly enlarged and convoluted and contained a milky whitish substance. Males of *G. mutilata* (n = 31) undergoing spermiogenesis were from the months of January (n = 1), February (n = 2), June (n = 1), July (n = 3), August (n = 11), September (n = 4), October (n = 2), November (n = 1) and December (n = 6). The smallest reproductively active male (undergoing spermiogenesis) measured 41 mm SVL (BPBM 8566) and was collected in

August. *Gehyra mutilata* smaller than 41 mm SVL were not examined. Therefore, the size at which *G. mutilata* males reach maturity is not known.

Four stages were seen in the ovarian cycle (Table 1): quiescent (no yolk deposition); (2) early yolk deposition (basophilic granules in the ooplasm); (3) enlarged ovarian follicles (> 4 mm length); and (4) oviductal eggs. Mean clutch size for 16 *G. mutilata* gravid females (ovarian follicles > 4 mm or oviductal eggs) was 1.6 ± 0.50, SD, range = 1-2. Six of 16 (37%) gravid females contained clutches of one egg; ten (63%) contained clutches of two eggs. The smallest reproductively active female (two oviductal eggs) measured 39 mm SVL (BPBM 35649) and was collected in February. Two females smaller than 39 mm SVL possessed very small ovaries and were considered to be sub-adults. One female (LACM 137518) collected in July contained two oviductal eggs and was undergoing concomitant yolk deposition for a subsequent clutch indicating *G. mutilata* likely produces a second clutch in the same reproductive season.

One neonate (SVL = 20 mm) was collected in July. McKeown (1996) reported neonates of *G. mutilata* from Hawaii ranged from 18-25 mm SVL.

DISCUSSION

From the prolonged period of sperm production and ovarian activity, it appears that *G. mutilata* may reproduce throughout the year in the Hawaiian Islands. However, our monthly samples are too small to discern a peak in reproductive activity, if one exists and it is possible that females are not reproductively active for at least a portion of the winter season (December and January), a point that remains uncertain because of our small sample sizes for these months (Table 1). Similarly *G. mutilata* has been reported to reproduce throughout the year in Bandung, West

Table 1. Monthly stages in the ovarian cycle of 32 *G. mutilata* from Hawaii. * = one July female with oviductal eggs was undergoing concomitant yolk deposition for a subsequent clutch.

Month	n	Quiescent	Early yolk deposition	Enlarged follicles > 4 mm	Oviductal eggs
January	1	1	0	0	0
February	3	0	1	1	1
March	1	1	0	0	0
April	2	1	0	0	1
May	2	0	0	0	2
June	2	2	0	0	0
July	3	2	0	0	1*
August	6	4	0	0	2
September	3	0	0	0	3
October	5	1	0	1	3
November	2	1	0	1	0
December	2	2	0	0	0

Java, Indonesia (Church, 1962), in the Cocos (Keeling) Islands (Cogger *et al.*, 1983) and on Panay Island, Philippines (Gaulke, 2011). Each of these localities is at a lower latitude than is Hawaii. In contrast, Karsen *et al.* (1986) reported that in Hong Kong, at a latitude equivalent to that of our samples, *G. mutilata* reproduced in spring and summer. However, in that study it was not clear whether *G. mutilata* reproductive activity was monitored throughout the year.

Previous reports from American Samoa (Schwaner, 1980), Guam (Sabath, 1981), Hawaii (Oliver & Shaw, 1953; McKeown, 1996), and North Borneo (Malkmus *et al.*, 2002) indicate that *G. mutilata* produces clutches of two eggs. Das (2004) reported *G. mutilata* producing 1-2 eggs in Borneo. In contrast, Karsen *et al.* (1986) reported a maximum clutch size of three eggs for *G. mutilata* in Hong Kong and there are early reports of 3-4 eggs from the Cocos (Keeling) islands (Wood-Jones, 1909; Gibson-Hill, 1950) that warrant verification.

The extended reproductive season of *G. mutilata* in Hawaii is not surprising given that Hawaii's subtropical location makes the climate equable year-round, although possible differences with observations from Hong Kong warrant clarification.

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Appendix. ***Gehyra mutilata*** **examined from the Hawaiian Islands deposited in the Bishop Museum (BPBM), Honolulu, Hawaii, USA, the Carnegie Museum of Natural History (CM), Pittsburgh, Pennsylvania, USA and the Natural History Museum of Los Angeles County (LACM), Los Angeles, California, USA.**

Hawaii: BPBM 23951, 23960, 23965, LACM 28246-48, 28251, 28253, 137517-18, 137523-24, CM 46368, 46370, 46375, 46379-80, 46386, 46391-92, 46395-96, 64503;
Kahoolawe: BPBM 6738, 9877;
Kauai: BPBM11245-46, 13099;
Lanai: BPBM 31542;
Maui: BPBM 13961-64, 13967;
Molokai: BPBM 730, 1564, 6588, 6610, 6615, 6629, 6657, 6713, 28132-33, 21885;
Nilhau: BPBM 23947;
Oahu: BPBM 1563, 1961, 2859-60, 2863, 5040-41, 5098, 8566, 11236, 12709-10, 24202, 31904-07, 35648-49, CM 34202.

PREDATION BY AN EASTERN BROWNSNAKE *PSEUDONAJA TEXTILIS* ON A COMMON DEATH ADDER *ACANTHOPHIS ANTARCTICUS* (SERPENTES: ELAPIDAE)

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INTRODUCTION

A wide diversity of snake species include other snakes in their diet (Freiría *et al.*, 2006). This specialized feeding behaviour, known as ophiophagy, occurs in several Australian taxa, including *Pseudechis* (Barton, 2009; Nicolson & Mirtschin, 1995; Thurn *et al.*, 1993; Sass, 2008), *Pseudonaja* (Neindorf, 1994; Wilson & Swan, 2010), *Antaresia* (Trembath, 2008; Wilson & Swan, 2010), *Aspidites* (Wilson & Swan, 2010), *Austrelaps* (Shine, 1987), and *Vermicella* (Shine, 1980). Elapid snakes in the genus *Pseudonaja* (known as 'brownsnakes') are regarded as opportunistic predators (Shine, 1989). Detailed studies on the prey items for *Pseudonaja* in habitats such as forested areas and pastures used for stock grazing, show they generally consist of a wide variety of terrestrial vertebrates, mainly small mammals, lizards and frogs (Shine, 1979, 1989; Wells, 2002; Whitaker & Shine, 2003). Other snake species, including elapids, have also been found in the diet of *Pseudonaja* (Neindorf, 1994; Shine, 1989; Wells, 2002). Field observations of ophiophagy in snakes are uncommon in the literature and there is a paucity of information regarding *Pseudonaja* preying on other snake species, in particular large elapids. Here we present details of an observation of predation by an adult eastern brownsnake *Pseudonaja textilis* on an adult common death adder (*Acanthophis antarcticus*) and attempt to discuss how a predator can cope with immobilizing and consuming a large, potentially dangerously venomous food item.

OBSERVATION

On 17 March 2010 at 1118 hours the authors and another person in the group observed an aggressive interaction between an adult *P. textilis* and an adult *A. antarcticus* from a distance of at least two metres. The *Pseudonaja* was approximately 1.2 m in length while the *Acanthophis* was approximately 60 cm in length. The observation occurred in Kroombit Tops National Park, 65 km south-west of Gladstone, Central Queensland (24°21'S 150°57'E). The snakes were located approximately 15 m from a vehicle track on a rocky ridge within dry sclerophyll forest. The snakes were discovered coiled around each other and motionless, attached by their mouths (Figure 1). During the 34 minute observation both snakes repeatedly bit each other, with the encounter ending when the *Acanthophis* was ingested by the *Pseudonaja*. A detailed account of what occurred follows:

1118 hours. Observations commenced. The snakes were found with their mouths locked together and their bodies curled around each other (Figure 2). Both snakes were motionless. It was unclear how long they had been in this position or when they first made contact. The brownsnake had two clearly visible bite marks on its body.

1120 hours. The brownsnake started to uncurl due to the presence of the observers; however, it appeared to be having difficulty in doing so due to the attachment of the death

Figure 1. First view of the interaction between the two elapids. Photo: Dan Ferguson.

Figure 2. The snakes attached to each other by their mouths. Photo: Ben Nottidge.

Figure 3. The *Pseudonaja* attempts to pull away from the *Acanthophis*. Photo: Ben Nottidge.

Figure 4. On its return from moving away from the death adder and the observers, the *Pseudonaja* bites the body of the death adder. Photo: Dan Ferguson.

Figure 5. After spending some time trying to find the head of the *Acanthophis*, the *Pseudonaja* strikes and bites the base of the death adder's head. Photo: Ben Nottidge.

Figure 6. The death adder bites the body of the brownsnake, while the brownsnake bites the head of the *Acanthophis* for the second time. Photo: Ben Nottidge.

Figure 7. The *Pseudonaja* starts to work its mouth towards the snout of the death adder. Photo: Ben Nottidge.

Figure 8. On the *Acanthophis* releasing its bite on the body of brown-snake, the latter commences to consume the head of the death adder. Photo: Ben Nottidge.

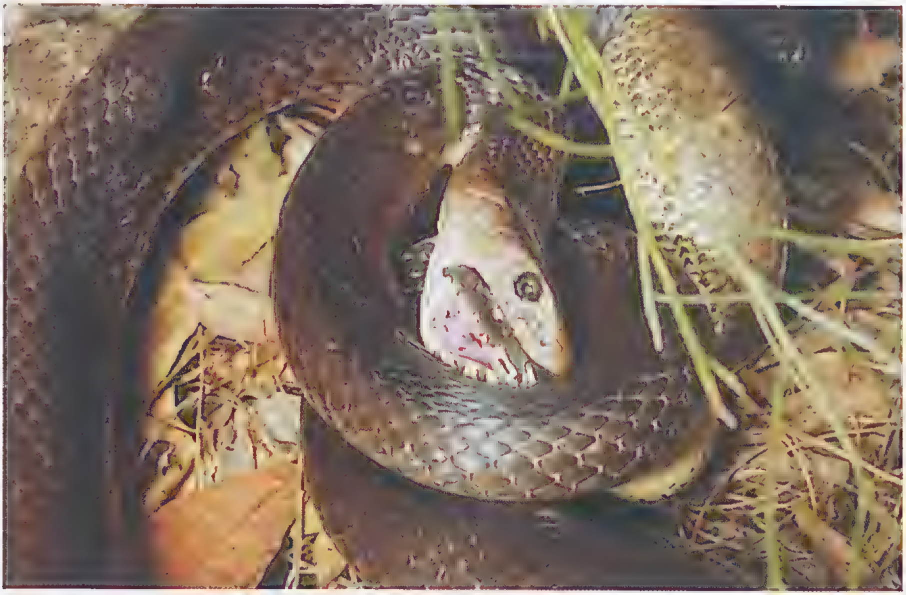

Figure 9. The brownsnake swallowing the head of the death adder. Photo: Ben Nottidge.

adder to its mouth (Figure 3).

1121 hours. The snakes separated and the *Pseudonaja* moved away approximately 4-5 m from the *Acanthophis* and the observers.

1122 hours. The *Pseudonaja* moved back towards the *Acanthophis* and appeared to be actively searching for it. When it located the *Acanthophis*, it spent approximately 30 seconds moving around, under, and over the death adder and appeared to be trying to locate its head.

1123 hours. After seemingly not being able to locate the head of the death adder, the brownsnake bit and held onto the right side of the other snake, about half way down its body for approximately 45 seconds (Figure 4). On every occasion when the *Pseudonaja* came close to striking the *Acanthophis* on the head, the latter rapidly moved the top half of its body, in a motion similar to a sluggish strike, away from the *Pseudonaja*.

1127 hours. After spending several minutes again trying to locate and strike at the head of the *Acanthophis* without success, the *Pseudonaja* again bit (this time briefly) the death adder on the right side.

1129 hours. The *Pseudonaja* finally located the head of the *Acanthophis* and despite the other snake's attempted avoidance, the *Pseudonaja* again bit and held onto it just below the base of the head on the right side (Figure 5).

1130 hours. As the *Acanthophis* attempted to dislodge the *Pseudonaja*, both writhed around until the *Acanthophis* got a holding bite on the body of the *Pseudonaja*, approximately 15 cm

Figure 10. The *Pseudonaja* slowly ingesting the death adder and using two coils to firmly secure the body of the *Acanthophis*. Photo: Jesse Rowland.

Figure 11. Final view of the brownsnake ingesting the death adder. Photo: Ben Nottidge.

from its head on the right side. In response the *Pseudonaja* released the adder from its original bite location and bit and held the *Acanthophis* on the right side of its head (Figure 6).

1131 hours. Once in this position, both snakes exhibited little movement until the brownsnake was able to put part of its body around the death adder in two coils in a slow but controlled manner - presumably in an attempt to further secure the adder (Figure 7).

1134 hours. The *Pseudonaja* gradually worked its mouth towards the snout of the *Acanthophis*.

1135 hours. With a combination of tightening one coil around the body of the *Acanthophis* and using its mouth, the *Pseudonaja* dislodged the *Acanthophis* from its body and also applied two constricting coils with its lower body (Figure 8).

1136 hours. The *Pseudonaja* began to consume the *Acanthophis* head first (Figure 9).

1146 hours. The *Pseudonaja* continued to slowly swallow the *Acanthophis*, then appeared to stretch it by pulling back with its upper body while maintaining the two earlier applied coils with its lower body, causing the anterior body of the *Acanthophis* to stretch considerably and pull straight (Figure 10).

1152 hours. By this time the brownsnake had swallowed approximately 15 cm of the death adder, which was now motionless except for occasional slow movement of its tail tip. The bite marks on the brownsnake were indicated

by the presence of several orange flies that appeared to be attracted to the bite sites and were present during the entire observation (Figure 11). Observations ceased at this point. The observers did not witness the *Pseudonaja* consuming the entire *Acanthophis*.

DISCUSSION

Field observations of snake predator – prey interactions are rare in the literature and there are very few records of ophiophagy, particularly in *P. textilis* (Neindorf, 1994; Shine, 1989, 1991). This field observation, to the best of our knowledge, represents the first published record of *P. textilis* preying on *A. antarcticus*. As mentioned previously, the observers did not witness the total ingestion of the death adder. However, we are confident that the brownsnake would have consumed the entire body based on its condition at the time of ingestion, and from evidence that cannibalistic adult *P. textilis* have been recorded ingesting snakes not much smaller than themselves (Neindorf, 1994).

It is unknown how the two elapids came into contact with each other. Contact may have occurred a considerable amount of time prior to us discovering the snakes as the *P. textilis* had two clearly visible, fresh bite marks on its body indicating a previous struggle before our initial observation of the snakes. Shine (1980) reported that *P. textilis* and *A. antarcticus* are similar in their diets but the means by which they forage are markedly different. We speculate that the brownsnake, a diurnally-active forager, came across the death adder while the latter was waiting to ambush prey using a caudal lure on its tail, which is a typical foraging method used by *Acanthophis* spp. (Reed & Shine, 2002; Shine, 1979, 1980; Wilson & Swan, 2010).

The combination of striking and constriction used by the brownsnake to restrain and kill the death adder agrees with previous reports of the use of constriction in prey restraint by brownsnakes (Shine, 1989; Wilson & Swan, 2010), and other Australian elapids (Shea *et al.*, 1993; Shine & Schwaner, 1985). It has been proposed that *Pseudonaja* species may use constriction for prey restraint in order to effectively envenomate heavily armoured prey due their short fangs (Shine & Schwaner, 1985).

From our observation, the brownsnake had obviously been envenomated, yet it appeared to show no adverse symptoms. All members of the group who witnessed the encounter between these two snakes are familiar with the behaviour of brownsnakes and it was agreed after the observation that the *P. textilis* didn't appear to be showing any effects of the *A. antarcticus* venom. It would appear then that brownsnakes have some resistance to the venom of *Acanthophis* spp. There are a number of reports of blacksnakes (*Pseudechis* spp.) having been envenomated while preying on other elapids without showing apparent effects (Barton, 2009; Nicolson & Mirtschin, 1995; Thurn *et al.*, 1993). Serum from *P. textilis* provides a degree of immunity from the action of a variety of Australian snake venoms (Nicolson & Mirtschin, 1995), which may explain an observation of a *P. porphyriacus* consuming *P. textilis* (Barton, 2009). It was initially thought that the ingested *P. textilis* was deceased, yet it was regurgitated a short while later, still alive and in a relatively 'intact' condition. One would assume the *P. porphyriacus* would have envenomated the *P. textilis* at least once during the confrontation. Despite this, the brownsnake somehow managed to turn around inside the body of the *P. porphyriacus* and exit through the mouth relatively unharmed (Barton, 2009). Does this mean *P. textilis* may have evolved some degree of resistance to the venom of other elapid species as a predator defense mechanism? Based on these observations and previous studies (Barton, 2009; Neindorf, 1994), it appears so. More research into the apparent resistance of *P. textilis* to venoms of other elapid species would be required to gain a better insight into the biology and evolutionary history of this common snake.

This fortunate observation indicates that there is still much more to learn about this well-studied snake, including its predatory relationship with other elapids. It is difficult to quantify

how often *P. textilis* preys on other snakes in the field, including its own species. The apparent resistance to the venom of other large elapid species is also poorly known. But if this observation can tell us anything about *P. textilis*, it is that this elapid truly is a very well-equipped, opportunistic predator.

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WHERE DO TERRESTRIAL ELAPIDS GO DURING FLOOD EVENTS? OBSERVATIONS OF THE CURL SNAKE (*SUTA SUTA*) (SERPENTES: ELAPIDAE) IN THE NSW RIVERINA

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INTRODUCTION

A number of snake families include aquatic and semiaquatic genera and species (Mattison, 2002). For example, the anacondas (*Eunectes* spp.) in the family Boidae, the water python *Lialis fuscus* in the Pythonidae, all three species of the family Acrochordidae, and *Agkistrodon* spp. in the Viperidae. The family Colubridae contains the largest number of aquatic and semiaquatic genera, particularly in the subfamilies Homalopsinae and Natricinae (Mattison, 2002). In contrast, with the exception of sea snakes (Hydrophiinae) and sea kraits (Laticaudinae), Australian members of Elapidae contain relatively few aquatic species (Mattison, 2002). This is despite many Australian snake species having an association with wetland and riparian habitats (e.g. *Hemiaspis* spp., *Pseudechis* spp. and *Notechis scutatus*; Wilson & Swan, 2010).

Aridity and the prevalence of oviparity in many snake species (Shine, 1991) may explain the paucity of aquatic elapids in Australia. However, many snakes occur on low-lying, clay soils (Cogger, 2000) and in a range of flood-prone vegetation types, including naturally treeless grassland and shrubland communities. During 'wet years', often associated with La Nina cycles, floodplain ecosystems can become temporarily inundated, often for several months. In grassland and shrubland vegetation communities, there is little opportunity for small terrestrial reptiles to seek arboreal refuge or find elevated ground. So, where do small terrestrial elapids go when flat, treeless environments are temporarily flooded? In this note, I present observations of the Curl Snake *Suta suta* during a flood event in 2010 in an area of derived Boree *Acacia pendula* woodland (Riverine plain woodland *sensu* Keith, 2004) that had recently been planted with Old Man Saltbush *Atriplex nummularia* near Conargo (35°00'38"S 145°23'31"E, 103 m above sea level) in the central Riverina bioregion, Murray catchment of NSW (see Michael *et al.*, 2011 for experimental design).

OBSERVATION

At about 0900 hours on 30 June 2010, during a fauna survey in the Murray catchment, four *Suta suta* were recorded beneath an array of artificial refuges (ARs) that our research team had installed in June 2008 (Michael *et al.*, 2012). Figure 1 shows the spatial arrangement of a typical AR array. On inspection, two individuals were found on the soil surface beneath a railway sleeper (sleeper length = 1.25 m long x 33 cm wide x 28 cm deep) and two were found on the soil surface beneath the corrugated iron (1 m^2). Heavy rainfall in the region during the previous six months (302.5 mm at Conargo since January 2010; Bureau of Meterology, 2010) had caused extensive localised flooding in the region and resulted in submerging our ARs in flood water which covered several hundred square metres. The depth of the water at the site averaged 6 cm and resulted in the cleft between the railway sleepers and the soil to be fully submerged with only the top of the sleeper protruding from the surface. The corrugated iron was completely submerged. Our survey protocol involved removing all animals before the ARs are placed back in contact with the ground (to avoid crushing the

animals) and then placing the animals on the ground next to the AR to make their own way back under cover. However, because the snakes were cold and immobile, snakes found beneath the sleepers were placed inside the bolt holes of the sleepers, and snakes found beneath the iron were returned beneath the iron under the water. On this occasion, individual snakes were not sexed or measured.

At about 0945 hours on 23 August 2010, during a repeat survey of the site, four individuals of *S. suta* were observed sequestered beneath the same array of ARs. On this occasion all ARs were completely submerged (water depth was approximately 23 cm) and flood waters covered a larger surface area (a further 78.6 mm of rain had fallen since June 2010; Bureau of Meterology, 2010). During this visit, all snakes were measured and sexed by inspecting tail morphology and gently everting the hemipenes. One male (SVL 46 cm) and one female (SVL 22 cm) were coiled beneath the same railway sleeper I observed two snakes during the first visit, and two female snakes (SVL 26 cm and 24 cm) were coiled beneath the centre of the same sheet of corrugated iron I also observed two snakes during the first visit. One hundred meters away at a different AR array another male (SVL 33 cm) and female (SVL 19 cm) were observed beneath corrugated iron (no snakes were observed at this array during the first visit). All of the snakes were completely submerged and lying in direct contact with the soil beneath the refuges. All individuals were alive and had poor righting ability when placed on a clip board, suggesting core body temperatures were low at the time. The mean minimum and maximum temperatures for June at Conargo are 4.5°C and 15.1°C respectively (Bureau of Meterology, 2010).

DISCUSSION

According to local landholders, floodwaters had not receded between visits to the site. Thus, assuming the same individuals were involved on both visits, these observations raise the question of how *S. suta* respire during winter flood events. I propose three scenarios that may explain these observations. First, submerged *S. suta* inhale oxygen from air bubbles trapped beneath the ARs. Second, *S. suta* is capable of coordinated movement at low body temperature enabling them to swim to the surface to repay their oxygen debt, and third, *S. suta* is able to absorb oxygen via aquatic respiration.

I believe the first scenario is unlikely, because any air bubbles trapped beneath the refuges would have been released on inspection of

Figure 1. A standard array of artificial refuges used to survey herpetofauna in the NSW Riverina.

the ARs during the first visit. The poor righting ability of the snakes on the second visit suggests they were inactive at the time of the observation. However, *Suta suta* is nocturnal (Greer, 1997) and hence potentially capable of coordinated activity at relatively low body temperatures. The fact that snakes that were placed in the bolt holes on the first visit were located beneath the sleepers on the second visit, and two additional snakes were observed on the second visit supports the notion that *Suta suta* is capable of some movement during the cooler months of the year. Unfortunately, it was not possible to measure the temperature of the water or the snakes at the time of the observations.

The third scenario implies aquatic respiration and may also provide a possible mechanism to explain prolonged submerged behaviour in this species. Cutaneous respiration is documented for several aquatic snake families, including Homalopsinae, Colubridae, Acrocordidae and Boidae (Heatwole & Seymour, 1978 and references therein). Of these groups, oxygen uptake is strongly correlated with aquatic adaptation, with sea snakes showing the highest level of oxygen uptake compared to semi-aquatic species (Graham, 1974). In terrestrial species, aquatic respiration has not been documented but cannot be dismissed as a rudimentary trait a broad range of snakes might possess. These observations suggest that terrestrial elapids associated with flood prone environments may not only have the ability of coordinated movement at low body temperatures, but they may also be capable of some level of aquatic respiration enabling them to sit and wait until flood waters recede. Laboratory experiments would help to further test these hypotheses.

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A RANGE EXTENSION OF THE GULLY SKINK *SAPROSCINCUS SPECTABILIS* TO THE ILLAWARRA SUBREGION OF SOUTHERN NEW SOUTH WALES

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INTRODUCTION

The genus *Saproscincus* (Wells & Wellington, 1985) currently consists of 12 species (Hoskin, 2013) of small lizards that are highly associated with mesic forests. The suggested common name of shade skinks for the genus (Wilson & Swan, 2013) reflects this association. A consequence of the habitat preference of this genus is that species such as the gully skink *S. spectabilis* (and *S. mustelinus*) often colonise gardens (Shea, 2010; pers. obs.).

Saproscincus spectabilis has a fragmented distribution from Mt Tamborine, Queensland to Sydney, New South Wales (NSW) (Wilson & Swan, 2013; Atlas of Living Australia, 2014). The population/s in Sydney are small and fragmented being centred around the eastern suburbs from Randwick in the south-east to Pymble in the north (pers. obs.) and Mulgoa in the west (Atlas of Living Australia, 2014; Murphy, 1996, 2010; Shea, 2010).

OBSERVATIONS

In March-April 2013 several *S. spectabilis* were observed at Stanwell Park on the south coast of NSW. The animals were found in three properties in The Drive (34°14'S 150°59'E). The animals were detected in tall open forest that had rainforest in the subcanopy. The vegetation community was dominated by Blackbutt *Eucalyptus pilularis*, Grey Ironbark *E. paniculata* and Turpentine *Syncarpia glomulifera*. The midcanopy contained a range of species including Sweet Pittosporum *Pittosporum undulatum*, Cheese Tree *Glochidion ferdinandi* and Bangalow Palm *Archontophoenix cunninghamiana*. This suburban area supports many exotic species of plants, especially palms.

Four *S. spectabilis* were observed in three properties over a linear distance of approximately 100 m. They were seen stationed on garden plants (Figure 1) and structures such as verandahs. At that time I was transporting plants (mostly multi-stemmed palms) from Stanwell Park to Nowra. When moving plants from my vehicle I observed one *S. spectabilis*, which fled and escaped at Nowra NSW.

DISCUSSION

Several residents from Stanwell Park have established rainforest gardens that support a range of exotic plants. It is suggested that *S. spectabilis* has been translocated to this area as a consequence of horticulture. I base this suggestion on the fact that I resided at Stanwell Park at one of these properties during the late 1970s to the early 1980s and this species was not observed during that period.

Saproscincus spectabilis occurs some 60 km south of Sydney in the Illawarra subregion of the Sydney Basin bioregion. This area is characterised by the proximity of the escarpment to the sea, which has created a mild climate with mesic forests. This habitat is highly suited to the requirements of *S. spectabilis* and the Stanwell Park population is expected to expand along the escarpment.

In recent years there has been an increase in the movement of people and items such as building materials and plants to various places resulting in the establishment of feral colonises of herpetofauna. For example the grass skink *Lampropholis delicata* has been translocated to Lord Howe Island (Schulz, 2009; Kraus, 2009), Hawaii (Baker, 1979); New Zealand (Peace, 2004) and several islands in the tropical Pacific (Fisher, 2011).

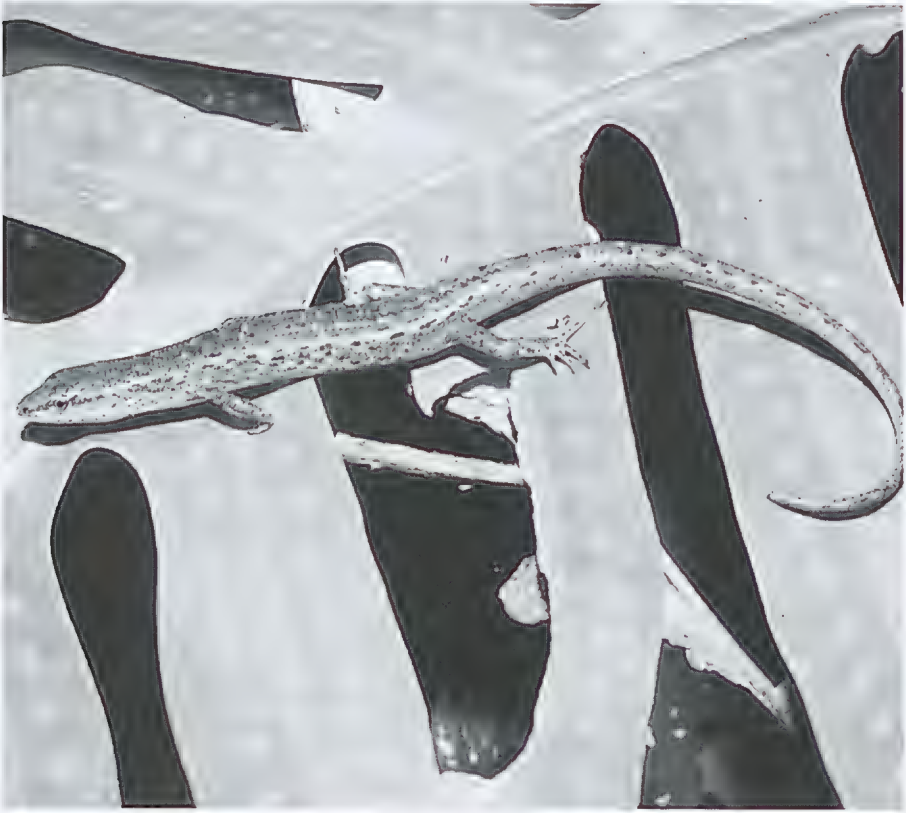
The exotic Asian House Gecko *Hemidactylus frenatus* has steadily colonised the east coast of Australia from far northern Queensland to Bulahdelah on the central coast of NSW (Lemckert, 2007) with individuals being found further south to Canberra (Welbourne, 2012) and Albury (Michael, 2005). The Dwarf Tree frog *Litoria fallax* has colonised areas south of its range on the Cumberland Plain in Sydney (in the 1980s) through the Illawarra to the far south coast of NSW (Daly & Senior, 2003) and an isolated population in Melbourne, Victoria (Gillespie & Clemann, 2000).

A common feature with these introductions is the ability of the species to stow away in timber and plants. In the case of *Saproscincus* that have communal nest sites (German, 1986; Shea & Sadlier, 2000; Turner, 2006; pers. obs.) a further method is of eggs being transported in pot plants. This could allow the establishment of a population from one translocation event. In a greenhouse age (Garnaut, 2008) when humans are moving materials around the country and the globe at an ever increasing frequency, the case of *S. spectabilis* illustrates our inevitable changing herpetofaunal landscape.

ACKNOWLEDGMENTS

I thank M. J. Murphy and S. Sass for reviewing the manuscript.

Figure 1. Gully Skink *Saproscincus spectabilis* from Stanwell Park (Photo: G. Daly, 9 April 2013).



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A NEW SNAKE TRAP

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INTRODUCTION

Published accounts of attempts to trap snakes go back at least as far as Imler (1945). Hattori (1999) reported that in the 1950s it was observed that traditional Japanese rat traps (box type with flexible cone entrances) occasionally trapped Habu *Trimeresurus flavoviridus*. The years between 1985 and the early 1990s saw a more intensive era of snake trap research resulting from attempts to address the devastating impacts of the Brown Tree Snake *Boiga irregularis* on ecological and human health on the Pacific island of Guam. Rodda *et al*. (1999) pulled together over half a century of Japanese and U.S. snake trap research to produce their "state-of-the-art" trap to alleviate the impacts of Brown Tree Snakes on Guam.

Also in the early 1990s and unaware of this body of research my experience assisting NSW far north coast wildlife carers with snake capture and relocation indicated to me that an effective snake trap was needed, particularly for large elapids. By the time I arrived on site the snake would commonly have sought refuge down a hole or under a concrete slab. After the snake's eventual reappearance in my absence, frustrated householders sometimes took matters into their own hands. This needless killing of snakes was the driving force that eventually led to the development of the "Snake Safe" snake trap.

THE DESIGN PROCESS

My enquiries among the herpetological community produced numerous verbal accounts of snake traps devised for specific, usually one-off, situations. These included lengths of PVC or metal downpipe with flap doors and live mice as bait. Other suggestions such as box traps with an upward sloping lip entrance, various funnel and eel-trap type designs, wire mesh containers with conical entries, as well as nylon mesh, were all suggested and appeared to hold some promise. However, trap constraints were numerous, with human and animal welfare considerations alone effectively ruling out development along any of the above lines.

Animal welfare considerations meant that a trapped snake must be protected from harm such as temperature extremes and predation. Furthermore the impracticality of servicing the needs of live animals employed as the attractant meant that they could not be used. Moreover the trap had to be easy to handle and simple to deploy, it had to be robust and able to withstand extended periods of deployment in all weather conditions and, importantly, it had to prevent the escape of a trapped snake. Many designs of funnel and lip entry traps do not prevent a snake from leaving the trap. If a snake trap was to be widely accepted it had to be safe for lay persons to undertake the daily trap inspection without placing themselves in danger from snake-bite. A chance observation one spring morning led me to solve two of the major problems that had, until then, apparently confounded effective snake trap design: compact configuration and provision of a no-maintenance attractant or bait.

An adult Eastern Brown Snake *Pseudonaja textilis* around 1.2 metres total length was seen moving along a grassy road verge littered with discarded building materials. After travelling several metres with intense tongue flicking, the snake's head disappeared beneath the grass followed by around two thirds of its body length. At that moment, and within a metre of the snake's tail, a mouse popped out of the grass and immediately ran into dense shrubbery nearby. The snake then completely disappeared beneath the grass

and a series of 8 or 10 more mice popped up at different locations and also scurried to nearby cover. The snake then reappeared on the grass in an agitated state with tongue flicking and jerky movements of its head and body. The entire episode lasted no more than five minutes.

In the context of designing a snake trap two aspects of the snake's behaviour were illuminating. Firstly the snake had apparently discovered the mouse nest by following an invisible chemical trail left by the mice. Secondly the snake did not hesitate to enter the subterranean burrow complex built by the mice. This demonstrated one of the reasons why the long narrow body shape of snakes is so ecologically successful. It also suggested that by using a trail of prey scent it may be possible to entice a snake into a tightly convoluted passageway and thereby contain its long body in a small manageable space.

THE DEVELOPMENT PROCESS

The plywood models first constructed to test the practical aspects of the trap and to determine appropriate dimensions resulted in a 500 mm x 500 mm x 75 mm flattened box. It had a 75 mm wide spiralling passageway which began in one corner and followed the internal wall of the box through four 90 degree bends and ended in a large void in the centre of the trap. Small holes were made in the floor of the central void so that the inside of the trap could equilibrate to the temperature of the substrate. The spiral passage design was ultimately chosen over other possible passageway configurations because it conveniently allowed the furthest point in the passageway to remain relatively close to the trap entrance (this had important practical implications for simplifying trigger design). A clear sheet of 4.5 mm acrylic was hinged to one wall of the trap to provide a transparent lid. An insulating cover comprising a 20 mm layer of polystyrene between two sheets of galvanised steel was fitted over the lid.

The insulative properties of this cover were tested using a digital thermocouple. When the trap (with cover in place) was deployed on a terrestrial substrate that had not been heated by the sun, the temperature of the central void of the trap remained largely independent of the trap surroundings, regardless of subsequent exposure to the sun. The temperature of the central void of the trap, when deployed directly onto heated terrestrial substrate, quickly rose to the temperature of its surroundings but slowly returned to the temperature of adjacent terrestrial substrate in full shade. When deployed above ground (e.g. roof space or tree) the temperature of the central void of the trap fluctuated according to the surrounding air temperature indicating that in extreme situations, such deployments have the potential to harm a trapped snake.

Door materials trialled included solid metal and plastic flaps as well as multiple plastic fingers. Each of these door types was hinged horizontally at the top of the passageway entrance and closed against the passageway floor. Snakes temporarily held and awaiting translocation would readily enter traps with the door fixed open but were reluctant to push open doors and allow them to rest on their backs while they entered the trap. It was apparent that an effective snake trap would need a trigger activated door that would close after a snake had entered the trap. The snake would have to provide the trigger movement required to cause the trap door to close. However, live bait was impractical, most snakes do not eat non-living prey (Shine, 1991) and a floor treadle arrangement was unlikely to work because snakes usually have their weight spread over a large area. The key to the required trigger movement was eventually found in snake locomotion whereby irregularities on the substrate are pushed against or pulled on by the belly or flanks of a snake in order to move its body.

By positioning a vertically oriented irregularity (the trigger arm) in the otherwise smooth surroundings within the trap I considered it likely that an advancing snake would push on the trigger arm for purchase and thereby provide the movement required to close the door after the snake had entered the trap. This trigger arm was positioned at the innermost end of

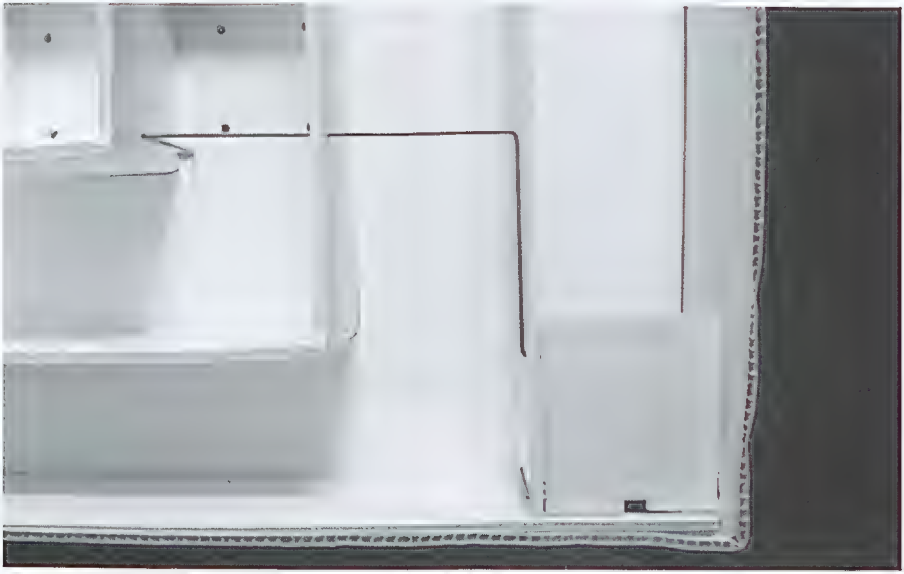
the passageway wall in order to allow most of a snake's body to be within the trap before the trigger was activated. The top of the trigger arm had a horizontal projection that protruded through the wall of the passageway near the entrance and served to hold the door open when the trap was set (Figure 1). The force applied to the vertical inner end of the trigger arm by the snake produces a lateral movement that slides the door support end of the wire from its position and allows the trap door to close against the floor of the entrance passageway. Several early attempts to trap large Eastern Brown Snakes *P. textilis* and Red-bellied Black Snakes *Pseudechis porphyriacus* resulted in closed traps containing no snake. I suspected and later confirmed by observation that these large elapids would enter the trap only to reverse back out again when the triggered door tapped them on the back. This problem was overcome by continuing the passageway through another 360 degrees and by making some modifications to the trigger arm projection. The traps could now contain snakes up to 2.3 metres in length before the door was triggered (Figure 2).

The first traps were scented by placing them (with insulation cover removed) in a large container from which mice could not escape. Approximately six mice along with ample food and water were placed in the container. An opaque covering was then placed over the central void of the trap such that during the day this was the only area within the container that was dark. A suitable nesting material was added and after 5 or 6 days I considered the trap "scented" and ready for deployment.

This combination of features proved effective at trapping large *P. textilis*, the Spotted Black Snake *Pseudechis guttatus*, *P. porphyriacus* and *B. irregularis*. Subsequently it was realised that soiled substrate media from the floor of mice housing enclosures was an equally effective attractant for trapping large elapids. The ready availability of this material allowed trails of attractant leading to the trap to be laid in the immediate vicinity of the deployment in order to further enhance trap effectiveness.

Given this success it seemed logical that this same design would be effective at trapping other species that actively search for their

Figure 1. Plan view of "Snake Safe" trap trigger showing open door resting on tip of trigger. The trigger wire slides from right to left below.



prey. Another large container was set up with a mesh lid, a bowl of water at one end and a snake trap at the other. The central void of the trap was again covered with opaque material so that this was the only suitable shelter within the container. An insect attracting light was then fitted to a large funnel with its narrow end protruding through the mesh lid to provide ample flying insects. Two or three adult Green Tree Frogs *Litoria caerulea* were then introduced into the container. The frogs hid in the darkened centre of the trap during the day and emerged at night to feed. After 5 or 6 days I considered the trap "scented" and ready for deployment. Several successful trapping events indicated that with frog scent as the attractant the Green Tree Snake *Dendrelaphis punctulatus* was equally as susceptible to this trap design as were the three large elapids and *B. irregularis*.

A scaled down version of this trap design was then produced to test whether smaller species or juveniles of larger species could also be trapped. Dimensions of the smaller trap were approximately 200 mm x 200 mm x 25 mm high with a 25 mm wide passageway (Figure 2). Spartan enclosures were again set up with water, an insect attracting light and funnel arrangement and a heating lamp. One of the smaller traps with a darkened central void

Figure 2. "Snake Safe" trap design - current and scaled down models (insulation covers removed).

was then placed at one end of the enclosure and a single adult Striped Skink *Ctenotus robustus* was introduced. The skink retired to the shelter of the central void of the trap at night or when a danger was perceived. The Small-eyed Snake *Cryptophis nigrescens*, the Yellow-faced Whip Snake *Demansia psammophis* and juvenile *P. textilis* were all captured by this smaller skink-scented trap demonstrating that different attractant scents can be used successfully with these traps.

DISCUSSION

Nearly all of the trapping episodes described above were opportunistic events undertaken over a five year period. They were generally instigated by property occupiers who felt that the presence of snakes was a danger to themselves, their family, staff or pets. The results suggest that this snake trap design will be effective with most snake species that actively search for their prey, which includes most of the species that occur in residential, industrial and agricultural areas where their presence concerns many people (Clemann *et al.*, 2004; Clemann, 2006).

While this work indicated that many snake species that actively search for their prey do so by tasting the substrate, airborne scent is also likely to be utilised, perhaps to a lesser extent depending on the location and the conditions in the immediate surroundings. In one instance an adult *P. textilis* had been seen in the ceiling space above the third floor of an office building (an area in excess of 1000 square metres). When the sole deployed trap was inspected approximately 48 hours later the snake was in the trap. In the almost still-air surroundings within the ceiling space it seems probable that the snake had located the trap by following air-borne scent.

While there are many parallels between the development of the Habu trap, the "state-of-the-art" trap for *B. irregularis* and the "Snake Safe" design I find it surprising that neither of the former groups managed to create a trap with a door and trigger arrangement. Rodda *et al.* (1999) acknowledged improved trap retention rates using flap doors to prevent escape, however the reluctance of snakes to push open a flap door meant that trap success rates could be even lower with these devices fitted. With the inclusion of an internal hide tube their flap entry "state-of-the-art" traps had escape rates of 2-4%, but no doubt discouraged many snakes from entering in the first place. Unfortunately trapping data (no. of traps, successful captures/no. of days deployed) for the "Snake Safe" design with scenting media, passageway, trigger and door arrangement were rarely collected. Nevertheless I confidently predict a significant increase in trap entry rate compared to the "state-of-the-art" trap and close to zero escape rates.

Both the Japanese and U.S. research groups (Hattori, 1999; Rodda *et al.*, 1999) persevered with live rodents as the attractant although both groups trialled various other species and odour extracts. The use of prey scent as the attractant in "Snake Safe" traps has been demonstrated to be successful, efficient and without animal welfare problems. While prey scent must diminish over time through dilution, masking or molecular deterioration, mouse scenting media in excess of three months old has resulted in the capture of at least one large elapid using "Snake Safe" traps. However, it seems intuitive that the fresher the scenting media the more likely it is that a snake will investigate the trap. I routinely recommend that scenting media be replaced or refreshed monthly but more work on this important aspect of trap effectiveness is needed.

The Japanese and U.S. studies both reported far fewer captures of juvenile than adult snakes using mice as the attractant and both groups also reported trapping smaller snakes using live geckos as the attractant (Hattori, 1999; Rodda *et al.*, 1999). This aligns with the ontogenetic dietary shifts exhibited by most snake species (e.g. Shine, 1991). The change in dietary preference is not simply due to the fact that smaller snakes can only physically consume smaller prey. Many small mammals will protect their young (pers. obs.) and the head of a snake is highly vulnerable to a disabling or lethal injury. For this reason juvenile snakes may actively avoid or at least be very wary when sensing the presence of small mammals such as mice. It is also likely

that such avoidance is the explanation for Rodda *et al.* (1999) finding increased trap success with juvenile *B. irregularis* using geckos as the attractant, but no improvement at trapping juvenile snakes using a combination of geckos and mice as the attractant.

Rodda *et al.* (1999) reported multiple captures of *B. irregularis* as common. I have found multiple captures to be uncommon or rare events with "Snake Safe" traps. On the two occasions where I trapped more than one snake, each involving two *P. textilis*, I believed this to be due to pre-copulatory behaviour where a courting male had accompanied or followed a receptive female into the trap. This dissimilarity with multiple captures is likely to reflect the vastly different situations in which the two trap types were deployed. Rodda *et al.* (1999) deployed their traps ina scientific array on the island of Guam where the population of *B. irregularis*, having no natural predators, had reached extremely high densities. In most instances "Snake Safe" traps were deployed in an attempt to capture an individual snake seen in close proximity to human habitation.

Some currently available eel-trap type designs are used in association with drift fencing to direct snakes to the trap. These traps typically have a mesh funnel entrance that terminates in an unsealed, ragged, linear seam that a snake pushes through to enter but is difficult for the snake to find and push through to exit. The downside to these devices is that they trap fauna indiscriminately, including small mammals, lizards and snakes (pers. obs.). This exposes any small fauna that may enter the trap to a high risk of predation. Even with daily inspection of these traps, it would be impossible to determine what fauna had entered the traps without examination of the stomach contents of larger trap victims. For this reason use of these traps as a survey tool is limited and may be objectionable on animal welfare grounds. Non-target species captured by "Snake Safe" traps were limited to adult Blue-tongued Skinks *Tiliqua scincoides* (at least two occasions), Cane Toads *Rhinella marina* (numerous occasions) and Black Rats *Rattus rattus* (numerous occasions). The latter species can badly damage a "Snake Safe" trap if not released within 24 hours.

Glue-boards also raise concerns on animal welfare grounds as it can be difficult or impossible to remove snakes from the adhesive surface without causing them injury. In addition, due to the risk of bites, human health and safety considerations cannot be met and only highly experienced snake handlers should attempt to remove a snake from these devices.

The process of trapping snakes using the "Snake Safe" design is very similar to small mammal trapping. The trap must contain a suitable attractant and the target species must be present and able to find the trap. The target species must also be hungry and here ectothermic biology provides an additional degree of difficulty. Numerous instances were observed where a large elapid had basked next to or on top of a deployed trap but had displayed no inclination to enter. I interpret this behaviour as from a snake that has not attained optimal body temperature, is gravid, about to slough or is simply replete. However, male snakes may be reluctant to feed as a result of a range of behaviours related to mating activity (Daly, 1978; Aldridge & Brown, 1995; Madsen, 1998; Webber *et al.*, 2012). Such behaviours, in addition to the lower energy requirements of ectotherms, indicate that snakes are inherently more difficult to trap than many mammals. In their study on a closed population Tyrrell *et al.* (2009) found asynchronous bouts of "trappability" (7 day period) for individual *B. irregularis* and hypothesised a link to short-term satiety or optimal time investment before changing foraging location. These limitations on snake "trappability" must be conveyed to lay persons considering their options for snake management. It is very important to ongoing safe and rational snake management at a local level that lay persons understand the limitations of snake traps.

Presently the relatively high cost of producing a snake trap that meets human health and safety requirements may inhibit their widespread use. The current all-inclusive cost per

unit for a "Snake Safe" trap is $299.00. This model is designed to target snakes up to 2.3 metres total length that eat small mammals and actively search for their prey (typically dangerous elapids). It should be feasible to source reliable supplies of lizard and frog scenting media from zoological or private collections so that other snake taxa can also be targeted. It should also be feasible to produce a cheaper version of this trap strictly for the use of experienced research staff with appropriate measures in place to prevent misuse by the general public. Together with the smaller scale version of the "Snake Safe" design these traps may provide a valuable survey tool previously unavailable to biologists and which have potential to assist in the management of both problematic local snakes and threatened species.

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INTRAOCULAR SPARGANOSIS (PLATYHELMINTHES: CESTODA: PSEUDOPHYLLIDEA: DIPHYLLOBOTHRIIDAE) IN THE GREEN TREE SNAKE *DENDRELAPHIS PUNCTULATUS* (SERPENTES: COLUBRIDAE: COLUBRINAE)

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Sparganosis is an endoparasitic condition involving some species of Cestoda (tapeworms) that commonly affects frogs and reptiles almost worldwide but is especially prevalent in South America, eastern Asia, and Australia (Lane & Mader, 1996). The pseudogenus 'Sparganum' consists of a number of species of tapeworms belonging to four genera (commonly *Dibothriocephalus* spp., Thomas, 1985; Johnson-Delaney, 1996). *Spirometra erinacei* is also commonly reported as the agent of sparganosis in Australian snakes (e.g., Purvis, 1989; Watharow, 2001, and references cited therein). The final or definitive hosts (in which cestodes mature) for these endoparasites are usually cats or dogs, although foxes may also serve as final hosts; occasionally humans can become accidental hosts (Acha & Szyfres, 2005). Ova are shed in the faeces of these final host species which can wash into rivers, lakes or puddles where they hatch into embryonic coracidia. The first intermediate host is a freshwater copepod (a small aquatic crustacean), commonly *Cyclops* spp., that ingests these coracidia. The coracidia then develop within the copepod to become procercoids. Reptiles, amphibians, birds, mammals, and some freshwater fish serve as the second intermediate host when they ingest water containing infested copepods; the procercoids migrate through their tissues and develop into plerocercoid cysts or 'spargana'. Encysted spargana can live for many years in host tissues, occasionally causing inflammation and fibrosis (Miller *et al.*, 2005), but mostly there is very little effect on the host because encysted spargana generate little if any immunological response or metabolic load. A third intermediate host may occur when another vertebrate preys on the second intermediate host, e.g. when a snake eats an infested frog, leading to encysted plerocercoids in the snake. The lifecycle is completed when an infested intermediate host is eaten by a cat, dog, or fox; the plerocercoid then attaches to the intestinal wall, matures into a tapeworm and starts laying eggs within about nine days (Lane & Mader, 1996). Some small reptiles such as geckos can suffer sparganosis (Brown, 2012). These species are unlikely to consume copepods and largely feed on other arthropod groups, suggesting that the life cycle may be even more complex than currently thought, and great care should be taken by humans to avoid possible infestation (see below).

Cats, dogs and foxes are ecologically novel in Australia, which suggests that the thylacine, Tasmanian devil, quolls, and other native carnivores could have been the definitive hosts for these tapeworms prior to human settlement and the introduction of exotic mammalian predators. However, this hypothesis would require spargana-causing Cestoda to have been present in Australia prior to introduction of the dingo, which cannot be demonstrated as no vouchers from this time are available for examination, and also the ability of species responsible for sparganosis to reach sexual maturity and reproduce in endemic carnivorous marsupials or rodents, which is not yet established; hence, it is also possible sparganosis is a relatively recent

condition in Australian vertebrates.

The Green Tree Snake *Dendrelaphis punctulatus* is moderately common in the lower Hunter Valley region and it was no surprise when we were called by telephone on a warm day in mid-summer by neighbours of the first author to attend a property on the northwestern rural outskirts of Cooranbong, NSW (37°04.82'S 151°26.95'E), on 26 January 2007 around midday to remove a snake from a subspherical ceramic hanging basket with several subcircular openings, situated on their verandah; we did not know which species it was but had been informed that it was 'quite a long snake'. The snake was identified as *D. punctulatus*. On such occasions the authors' practice is to check the health of the snake, record measurements and injuries or scalation anomalies (for possible future recognition), remove easily removable ectoparasites, and then release it into suitable habitat close to the point of capture. The snake measured 922+352 mm (1.274 m total length) and weighed 68.5 g. When the head was viewed from above, the left eye was protruding (Figure 1); a bulging eye commonly suggests either a retro-ocular tumour, or in this case, an indication of increased intraocular pressure (unilateral glaucoma). Movement of a hand close to the left eye produced no response, which suggested no effective vision. Examination revealed what appeared at first glance to be an opaque white cataract in the left eye (Figure 2); however, cataracts in squamate reptiles in the experience of the first author are usually homogeneously opaque, although scattered or localised opacities are sometimes seen within the lens (not the case in this instance). Further examination showed that the opaque body rolled inside the eye as

Figure 1. Head of *Dendrelaphis punctulatus* in dorsal aspect showing protruding left eye.

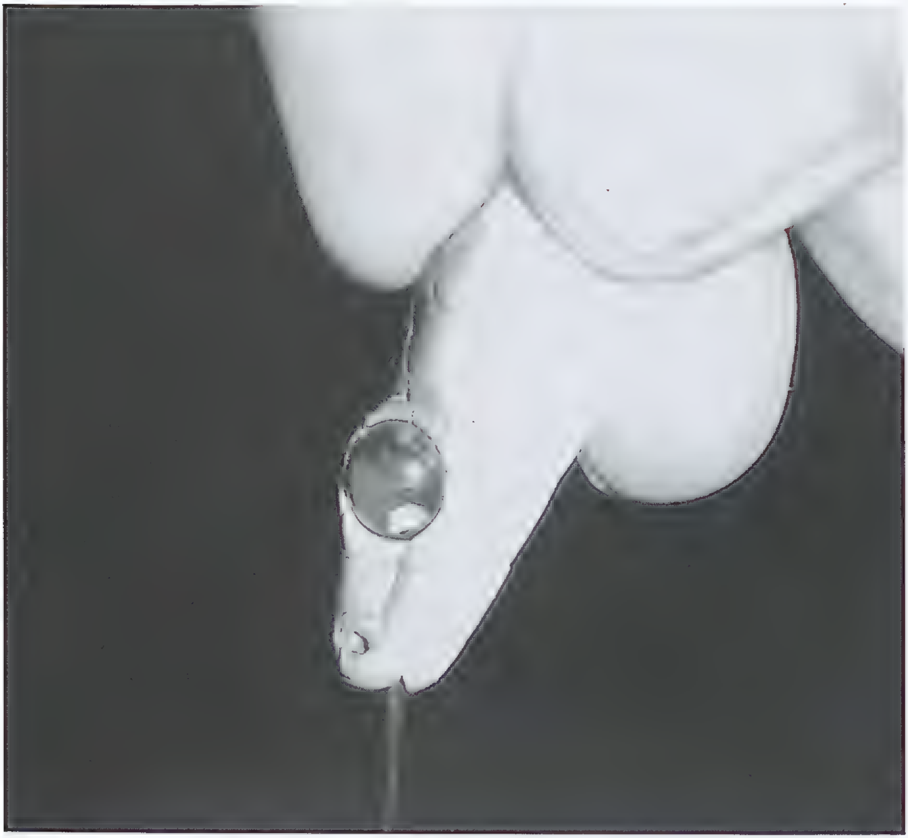
the head of the snake was tilted (Figure 3). It was also noted that the iris was missing except for a small area at the upper margin. There were about 12 small soft subcutaneous masses scattered over the dorsum and sides of the snake suggesting sparganosis. Close examination showed the intraocular opacity had substructure and appeared coiled, suggesting an intraocular sparganum. There was no evidence of a lens, presumed either missing, or perhaps the lens capsule itself formed a capsule for the sparganum, although in the latter case this would require penetration of the capsule of the lens and displacement of the crystallin proteins, which has not been previously reported.

The fact that the left iris of the *D. punctulatus* in the above case was largely destroyed suggested that the intraocular sparganum had been there for a long time. Damage by the sparganum probably included the aqueous fluid drainage channels in the eye leading to probable glaucoma. The pale retina suggests poor retinal circulation, often seen in glaucoma. The snake was otherwise in good condition and not malnourished, which suggested it could feed adequately with effectively monocular vision. Because surgical removal of the intraocular sparganum was not practicable, the snake was released into suitable open woodland habitat near a creek (after removal of six of the largest subcutaneous spargana).

This *D. punctulatus* was a mature adult (maximum total length in NSW 125.5 cm; Shine, 1991) suggesting it was several years old. Frogs are a major component of the diet especially in populations close to water courses; as the total number of frogs ingested increases with age it would be expected that the numbers of spargana would also increase. The first author has observed this relationship between age and spargana infestation rate in Swamp Snakes *Hemiaspis*

Figure 2. Lateral view of head showing intraocular sparganum, missing lens and iris and poor vascularisation of retina.

Figure 3. Downward tilted head showing mobility of sparganum.



signata (Elapidae), a locally sympatric species that also feeds on frogs (Shine, 1987). Of 30 *H. signata* examined from the vicinity of Cooranbong, NSW, no small juveniles had spargana, medium sized snakes had very few spargana, but large adults always had a few to many spargana. One large adult (696 mm TL) *H. signata*, found near the same locality as the above *D. punctulatus*, had severe sparganosis with about 40 spargana scattered over the body (but no evidence of intraocular sparganosis). Another large male *H. signata* (625 mm TL) found near Coffs Harbour, NSW, also had numerous spargana.

The surgical removal of subcutaneous spargana is easily accomplished by making a small nick in the skin under a scale at the apex of the bulge and squeezing out the worm, which may be many centimetres in length. An alternative method is the careful intracystic injection of ethyl alcohol to kill the parasite, which then gradually gets resorbed (Glanze *et al.*, 2005); no dosage is given but we would suggest about 3 μL. Occasionally some animals react to the sudden release of subcutaneous spargana and may die for no obvious reason (as happened to the large local *H. signata* mentioned above), possibly due to anaphylactic immune reaction. It is thus recommended that a treated snake be retained for a day or so to ensure that it has recovered and that no reaction occurs,

however given such reactions and the relatively benign effects of infestation on snake hosts, the best option may be to leave spargana undisturbed. Sparganosis may also be treated with systemic anthelmintics by qualified veterinarians, however, we have found no confirmation in the literature of the efficacy of such treatments in reptilian intraocular sparganosis.

On a note of caution, it should be noted that any untreated animal from the wild is a potential carrier of possibly serious zoonoses and herpetologists should always practise good hygiene. Salmonellosis particularly poses risks to unwary human handlers, however sparganosis is unlikely to be contracted unless an infested reptile or part thereof is consumed raw. Keep pet reptiles well away from dining areas, always wash after handling, particularly after handling faeces, keep cages spotless, never allow reptiles near the mouth and keep reptiles isolated from dogs and cats. And remember if you ever get the urge to eat your pet snake just make sure it is thoroughly cooked (exposure of all flesh to >76°C for more than 7 minutes)!

In conclusion, intraocular sparganosis is recognised in both reptiles and humans (Lane & Mader, 1996; Wiwanitkit, 2005; Johnson-Delaney, 1996; Glanze *et al.*, 2005). It is however uncommon, and this is the first time we have observed this condition.

ACKNOWLEDGMENTS

We thank the two anonymous reviewers for comments on a draft of the manuscript.

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BOOK REVIEW: FROGS OF THE SOLOMON ISLANDS

By Patrick Pikacha, Clare J. Morrison, and Stephen J. Richards, 2008.
Foreword by Rafe M. Brown.
ix + 10-68 pp. + 3 pp. notes + endplate (unpaginated), octavo format [21 x 15 cm],
38 colour photographs, 12 additional illustrations, 3 maps, 2 tables, 4 dichotomous keys.

Published by the Institute of Applied Sciences,
The University of the South Pacific, Suva, Fiji.

Available in paperback only, no dustwrapper.
RRP AU$30.00. ISBN 978-982-01-0833-2.

This is the first book by these co-authors, although the second author has previously published a field guide to the herpetofauna of Fiji (Morrison, 2003; for review see Metcalfe, 2007); it is the second book with herpetological content issued by this publisher in Suva, Fiji. The book covers the entire frog biodiversity currently known from Solomon Islands (not including the island of Bougainville, Papua New Guinea, a geologic and biogeographic part of the Solomon Islands group but under political administration of PNG; for frog species list and accounts from that island, see Menzies, 2006): 21 species in 4 families, most native or endemic to this region; Bufonidae (1 sp., exotic), Ceratobatrachidae (regarded by some workers as a subfamily or tribe of Ranidae; 5 genera, 17 spp., 15 native, 2 endemic, 1 currently undescribed), Hylidae (1 genus, 2 spp., native) and Ranidae (1 sp., native). Sections comprise (in order) three maps in a two page spread, Foreword, Preface, Acknowledgements, Table of Contents, Introduction (which includes subsectional summaries on Solomon Islands habitats (six defined, describing geology, landforms and vegetation, illustrated with representative photographs in the subsection with another on back cover), Frogs and toads (a basic summary of classification and biology of the Anura), Frogs and toads of the Solomon Islands (an overview of the regional frog fauna, including Table 1 on p. 16 arranged by family, genus and species giving distributional status, whether introduced, native or endemic), and Conservation (with three subsection headings describing current threats to the frog fauna and a fourth, "What can we do?" which gives a summary of threat amelioration that emphasises habitat protection and need for further research), then Table 2 in a two page spread (pp. 20-21) that gives frog distributions in the region by island, organised in major island groups, Use of Keys (in explanation of character states used in diagnostic steps in keys, with 12 line drawings illustrating morphological features, mainly limb digits), the species accounts (pp. 24-63), Glossary, Bibliography (short, but gives most references relevant to Anura of the region), Further Information (two subsections of useful web-site addresses, the first for frogs, the second for biodiversity conservation in Pacific Oceania), Index of species and genera, Appendix (giving instructions for transport and temporary maintenance of live specimens), and a final unpaginated section with three mostly blank pages headed "Notes" and a colour photograph of *Palmatorappia solomonis* (Ceratobatrachidae) as an endplate. The 21 species accounts are alphabetically organised by Latin name under familial and generic headings, and include dichotomous morphological keys to the four speciose genera of the region; accounts are arranged over two to three pages, each comprising Latin name (with describer and date, pleasing to see), English vernacular name, local vernacular name(s) if applicable, and then information summarised under subheadings

Description, Comparisons with other species, Distribution, Habitat (which somewhat strangely includes details of reproductive behaviour), and Conservation status (assessment listing by International Union for Conservation of Nature, 2007), each account accompanied by two (most accounts), three, or five (*Ceratobatrachus guentheri*) colour photographs.

Quality of focus and reproduction of colour photography are very good, reproduced at a large enough size to both illustrate salient features aiding identification and do them justice. An excellent photograph of *Ceratobatrachus guentheri* (Ceratobatrachidae) is reproduced on the front cover, but my favourite is the charming portrait of *Palmatorappia solomonis* on the endplate; this latter species in its green dorsal colour phase bears a remarkable superficial resemblance to species such as some South American *Cochranella* spp. (Centrolenidae) and some Madagascan *Boophis* spp. (Mantellidae: Boophinae), examples of evolutionary convergence. I was pleased with this book overall; the content has been previously dealt with in more detail by Menzies (2006) who includes Solomon Islands fauna with his coverage of the New Guinea frog fauna, but the book under present review is the only work solely devoted to coverage of Solomon Islands frogs. I have only a few minor criticisms: there is no key to the families or genera; amphibian larvae are not illustrated, although most are described in the species accounts (larvae of several remain unknown), and a photograph of the eggs of *Rana kreffti* is the only species thus illustrated (p. 63 lower) although descriptions of all (where known) are given in the species accounts. The work is remarkably free of typographical and spelling errors, but has an unusual form of pagination as does the previous book from this publisher (Morrison, 2003), nine preliminary pages (i-ix), then straight into standard pagination beginning p. 10. The strong points of the book are the colour photography of frogs and habitats, the diagnostic keys, the layout of the species accounts and the summarised biological data they contain, and the utility of having the region's constituent frog fauna covered in one volume, which complements the work on reptiles of the region by McCoy (2006). The book is printed on high-quality gloss paper.

The herpetofauna of Solomon Islands is currently under considerable threat due to extensive deforestation, as emphasised by McCoy (2006) and the authors in this book, and hence it is a timely production. This attractive, relatively reasonably-priced little book will be a useful aid to all naturalists visiting Solomon Islands, and is recommended as all constituent frog species are included; the authors and publisher are to be congratulated for producing this book which fills a regional gap among the field guides to the world's herpetofauna, and it will be a required addition to the libraries of herpetologists desiring global coverage.

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BOOK REVIEWS:

SNAKES, LIZARDS, CROCS AND TURTLES OF AUSTRALIA

By Steve Wilson, 2006.

FROGS AND TADPOLES OF AUSTRALIA

By Marion Anstis, 2007.

Both 48 pp. + endpapers, octavo format; 115 and 185 colour photographs of reptile and amphibian subjects respectively, mostly by each author, 2 (painting, map) and 5 (painting, 2 maps, drawing, colour photograph of pond) additional illustrations respectively, plus colour landscape background photographs.

Published by Young Reed,
an imprint of New Holland Publishers (Australia) Pty Ltd, Frenchs Forest.

Available in hardcover only, laminated boards, no dustwrapper,
outer covers with colour photographic images, inner covers and outer endpapers with half-tone dragon lizard photograph (Wilson)
or painting of stylised frog and habitat (Anstis).

RRP: AU$19.95 each. ISBNs respectively 1-921073-01-2 and 9781921073076.

These two books form a herpetological pair released by the publisher, and it is convenient to review them together. Both authors have published previous books and papers on their subjects well known to Australian herpetologists. The present works are marketed as 'children's books', and indeed serve this purpose admirably and probably represent the peak of output to date in this genre for each of the Australian herpetofaunal Classes covered. However the high quality and reproduction of the colour photographs of a wide range of Australian taxa and the highly informative but succinct accompanying text render both works a useful addition to the libraries of adults, including specialist natural historians; both are recommended as best first introductions on their subjects for young Australian readers. The price at which both books are made available is quite reasonable for the high calibre of content, and the authors and publisher are to be congratulated on their production.

I have a few general criticisms applicable to both books. The first of these is the layout; I love the large page size, but it is a great pity that more advantage was not taken of it to present some of the magnificent photographs at larger size, including 'landscape' format over full pages. Much space is taken on some pages with large text-headings and graphics, unnecessarily so. On almost all two-page spreads, the editorial device of superimposition of animal subject photographic images on large 'native open landscape' photographs as backgrounds is used, and whilst this is tastefully done, creates a certain habitat ambience and conveys a nice 'forest-glade feeling' and 'pond-side atmosphere', and serves to unite the subjects depicted on the particular page in a theme, in some cases, it is fairly obvious that it has been done and I would have preferred the photographs alone at larger size on those pages instead. Almost all photographs could have been presented at larger size, with no overflow of image and

textual material over-page and with pagination preserved. Some lovely photographs that are relatively enlarged have the full image of the subject truncated at page margins, and this could easily have been avoided by positioning complete images of subjects wholly within the large pages. The coloured map of Australia on light blue background on p. 6-7 in each book is perhaps unnecessarily simplified given the potential offered by the large page-size, and in my opinion maps on any background other than white almost never "work" in books and papers, compared with the clarity conveyed by black outlines on white background with such colour, shading, or symbols as may be needed. The two maps vary in colours/patterns used to depict regions and in the keys on the Contents page, and areas and their definitions so highlighted do not correspond, undoubtedly serving the requirements of each author in address of their subjects, but possibly confusing to young readers comparing the two.

I always like to see the Latin binomen (or trinomen, for subspecies) accompanying both photographs and English vernacular ('common names') in text, including in 'children's books' at the level of reading and comprehension skills assumed from evaluation of the accompanying English text in these books, due to the information value conveyed by the provision of the two Latin words, and to familiarise young readers to the existence of the Linnaean system of classification underlying species and higher groups of fauna overarching and parallel to vernacular characterisation. Vernacular names may vary widely on geographical and cultural bases; there are no 'official' lists of 'common names' for Australian Amphibia and Reptilia (neither should there be), and all works using a 'common name' categorisation and organisation should include all those known for each species. Unfortunately neither book provides this, although both have a highlighted paragraph at the end explaining Latin names immediately preceding an Index on final pages, which provides all Latin names for photographed or textually mentioned species accompanying the alphabetically listed English vernacular names used. However, flicking from photograph to Index is inconvenient and cumbersome, and Latin names could easily have been included in the text and captions given the layout and large page-size adopted.

Another criticism, not confined to these two books *per se* and generally applicable to most herpetological books and papers that use colour photographic illustrations, is the lack of field data associated with photographs. Broad and occasionally precise locality data are given in some works (although in neither of the books under review); however precise localities, dates, times of detection and photography, broad habitat-type, refugium and perhaps other associated field data such as ambient temperatures where available and museum voucher accession numbers where applicable could easily have been provided in figure captions in concise or condensed form in most cases. Indeed, details of camera, lens, flash, and whether taken in the field or on a 'set', etc. could also be included. These deficits could be remedied in the case of future herpetological publications with a wide subject content, given the wide range of fonts and small print sizes available in this digital desktop age. Many herpetological photographers do record such data and if utilised, they would convey much useful natural history information at little expense of space.

These relatively minor deficiencies are easily outweighed by the strong points of both. I could find no spelling or 'typographical' errors in either. Text is concise but highly informative, lavishly illustrated with colour photographic images, and is accessible to a wide age-range including any child and adult with reasonably well-developed reading and comprehension skills in English (~8 years and older); the large number and variety of colour photographic images extend accessibility to a younger 'readership' (down to ~3 years). The first title page is p. 1 in both books; the publication details page is placed differently in each, on the final page (p. 48) in the case of

the Wilson book, and after the first title page (p. 2) in the case of the Anstis book; then follows a second title page, a double spread (p. 2-3) in the case of the Wilson book, and a single page (p. 3) in the case of the Anstis book; then sections "How to use this book" (pp. 4-5 in both); map and contents pages (pp. 6-7 in both); then a differing series of section headings selected by each author to address their subject (see below); then "Activities" (pp. 38-41, pp. 42-44, respectively) including image recognition and a quiz on the text; a glossary (pp. 42-44, p. 45, respectively); "Want to know more?" which includes lists of relevant books, CDs and websites; "What's in a name?" briefly explaining Latin names for species, and an index.

Some individual comments pertaining to each. After the preliminary sections outlined above, the reptile book by Wilson is organised in sections "Meet the reptiles", introducing successively in sub-sections reptiles in general, crocodiles, turtles (I don't like this Americanism which has crept into recent literature and appears to be replacing the correct Australian vernacular "tortoise" for freshwater Chelidae), lizards with an example(s) of each Australian Family in a two-page spread, snakes with an example(s) of each Australian Family in a two-page spread, and then broad Australian landscape habitat sections of two pages each: "Scorched earth" (rocky/stony deserts), "Sun, sand and spinifex" (sandy deserts), "Rainforest - land of shadows", "Cold comfort" (cool temperate areas including alpine zone), "Top End - land of extremes" (tropical monsoon areas of Northern Territory, Western Australia and north Queensland), "Gum trees - tough leaves" (warm temperate eucalypt forests and woodlands), "Sweeping plains" (semi-arid grasslands and shrublands), "A blaze of colour - heaths", "Water world" (freshwater aquatic habitat), "Thin blue line" (marine and littoral), "City slickers" (urban habitats), and "Going...going..." (endangered and rare reptiles and threatening processes), followed by the concluding sections as per above. Almost all photographs are those of the author. Except for the Eastern Carpet Snake (*Morelia spilota mcdowelli*) (p. 12 centre left) and the two seasnake (p. 33 top) images, quality of colour photography and image reproduction is excellent in terms of clarity. My favorite in a gallery of stars is the enlarged image of a Grassland Earless Dragon (*Tympanocryptis pinguicolla*) (p. 27 bottom) although it is a pity it was not rotated and the full length of the page used to include the tail; I also particularly like the images of Javelin Legless Lizard (*Aclys c. concinna*) (p. 28); male Tawny Dragon (*Ctenophorus decresii*) (p. 10 bottom left); Yinnietharra Rock Dragon (*Ctenophorus yinnietharra*) (p. 15 bottom), although the full impact of the photograph is a little spoiled by superimposition of the image on an apparently different rocky background; and Military Dragon (*Ctenophorus femoralis*) (p. 40 bottom), although the attempt to superimpose a cropped smaller image of the latter on a different sandy background (p. 17 centre) does not really 'work'.

After preliminary sections, the amphibian book by Anstis is organised in two-page sections: "Meet the frogs", introducing successively in sub-sections frogs in general, grouped by broad behavioural mode and ecotype as 'Tree frogs', 'Ground frogs', and 'Aquatic frogs' (which obscures definition of the five frog Families that currently occur in Australia; although Hylidae and Myobatrachidae are mentioned on these pages, Microhylidae, Ranidae and exotic Bufonidae are not, nor are these subsequently mentioned in the text); "All about frogs"; "Calling all females" (acoustic communication in frogs); "From egg to frog" (breeding, eggs and development); "The world of tadpoles" (free-swimming larvae); "Who needs a tadpole" (larvae with direct development); "Southern treasures" (frogs and tadpoles of southeast mainland Australia and Tasmania); "East coast" (frogs of east Australian mainland coastal plain, hinterland and foothills), in which there appears to be an unfortunate misprint in my copy resulting in a large irregular yellow blotch over the top of the image of the Cooloola Sedge Frog (*Litoria cooloolensis*) (p. 23

bottom right); "Rainforest wonders" (north Queensland rainforest frogs); "Alpine rarities" (alpine southeast mainland frogs); "Great Divide" (eastern Australian wet forest frogs); "Across woodlands and plains" (frogs of woodlands and grasslands on plains and watercourses of eastern Australia west of Great Dividing Range); "The big dry" (arid-zone frogs); "Top End magic" (frogs of tropical monsoon Northern Territory); "Jewels of the south-west" (frogs of southwest Western Australia); "Going...going...gone!" (frog declines and probable extinctions, with examples); and "Frog friendly" (community engagement with frogs, including a map of Australia surrounded by circular images showing representative frogs with arrows indicating their general location, and photograph of a Cane Toad (Bufo marinus) with brief biological summary); these are followed by the concluding sections as per above. There is an error in pagination given in the index with two *Pseudophryne* spp.: *P. dendyi* ("Southern Toadlet") is given as being on p. 21 but has two images on p. 27, and *P. semimarmorata* ("Southern Froglet") is given as being on p. 27 but has its single image on p. 21, perhaps due to confusion on the part of the editor with the similar 'common' names, further illustrating the utility of stable Latin names accompanying common names as discussed above, particularly where the latter are used as the main system of presentation of the zoological subjects. The photography is again superb; although most photographs are by the author, several other leading Australian herpetological photographers have contributed work to this book. The white arrow indicating position of the frog in the photograph on p. 19 bottom right is unnecessary and spoils the image somewhat. My favorite images are those of Glandular Frog (*Litoria subglandulosa*) (p. 28, wrongly given in the index as also having an image or textual reference on p. 43) (I prefer the more appropriate English vernacular name of "Superb Tree Frog" for this beautiful frog which is not particularly glandular in appearance), New Guinea Tree Frog (*Litoria genimaculata*) (p. 24 bottom), Tasmanian Tree Frog (*Litoria burrowsae*) (p. 21 top right), unfortunately partly truncated at page margins, and the tadpole of the Sunset Frog (*Spicospina flammocaerulea*) (p. 37 top); the photograph by the author of the Electric Treefrog (*Litoria electrica*) (p. 34 bottom) is in my opinion the best yet published of this poorly known species.

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BOOK REVIEW:
SNAKES: ECOLOGY AND CONSERVATION

Edited by Stephen J. Mullin and Richard A. Seigel, 2009.
xiv + 365 pp., octavo, hard cover with dustwrappers.
Published by Comstock Publishing Associates, Ithaca.
RRP US$60. ISBN 978-0-8014-4565-1.

Snake ecology has been the subject of three similar volumes over the past three decades: "Snakes: Ecology and Evolutionary Biology" (1987, edited by Seigel *et al.*), "Snakes: Ecology and Behavior" (1993, edited by Seigel and Collins), and the present volume (paralleling and following a similar series of three volumes on lizard ecology: "Lizard Ecology: A Symposium", 1967, edited by Milstead; "Lizard Ecology: Studies of a Model Organism", 1983, edited by Huey *et al.*; "Lizard Ecology: Historical and Experimental Perspectives", 1994, edited by Vitt and Pianka). Each is the compilation of a number of papers, usually synthetic reviews, dealing with various aspects of the ecology of snakes and lizards but centred around the volume theme. The first snake ecology volume closed with a chapter on "Status, Conservation and Management" by Ken Dodd, and the second volume similarly included a chapter on "Strategies for Snake Conservation" by the same author. The present volume continues this theme, centring around conservation, but the included papers also have wider relevance to other biological discipline areas, and other organisms, and deserve a much wider readership than just ophidiophiles.

The short introductory chapter ("Opening Doors for Snake Conservation") is followed by 11 review chapters, by an impressive list of 24 authors, including Thomas Madsen and Rick Shine representing Australia. The first four chapters ("Innovative Methods for Studies of Snake Ecology and Conservation", "Molecular Phylogeography of Snakes", "Population and Conservation Genetics" and "Modelling Snake Distribution and Habitat") are more methodological in content, and are followed by four chapters that link ecological principles to wildlife management issues ("Linking Behavioral Ecology to Conservation Objectives", "Reproductive Biology, Population Viability, and Options for Field Management", "Conservation Strategies: Captive Rearing, Translocation and Repatriation" and "Habitat Manipulation as a Viable Conservation Strategy"). The next two chapters change direction, considering the value of snakes for biological monitoring ("Snakes as Indicators and Monitors of Ecosystem Properties") and the age-old problem of public perception of snakes ("Combating Ophiophobia: Origins, Treatment, Education, and Conservation Tools"). The final chapter ("Snake Conservation, Present and Future") brings together these and other issues to summarise the strengths and weaknesses of knowledge and management of snake conservation, emphasising once again that while we have come a long way in knowledge of snake biology, there are still gaping chasms of ignorance, both in scientific knowledge and public perception. References (an impressive 65 pages of them) are collated together at the end of the book, rather than for each chapter, and are followed by short, separate, taxonomic and subject indexes.

While the perception that snake ecologists "sometimes operate under a feeling of inferiority compared with those who study the other group of squamate reptiles" is receding, they are still to achieve universal parity with lizards, and with those charismatic amphibians, birds and mammals, darlings of the public eye. The more positive view that "snakes are the new model organisms" (both quotes from p. 282), while true in some areas of ecological research, is not yet the case across the board, especially in conservation. This volume will certainly help to further their cause.

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BOOK REVIEW
AUSTRALIAN LIZARDS: A NATURAL HISTORY.

By Steve Wilson, 2012.
x + 196 pp., full colour, quarto, paperback.
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Australian herpetology is now well endowed with field guides showcasing the diversity of our reptile fauna. At the national level, Cogger's recently and long-awaited seventh edition of 'Reptiles and Amphibians of Australia' provides a comprehensive overview and guide to both reptiles and amphibians across Australia, while Wilson and Swan's 'A Complete Guide to Reptiles of Australia' provides a concise and well-illustrated up-to-date account the Australian reptile fauna. Both are primarily identification guides with the broader aspect of natural history given on a species-by-species basis. John Cann's 'Australian Freshwater Turtles', published in 1998, a collage of natural history, taxonomy and one man's dedication to the subject, still stands as the premier reference to this particularly charismatic group of Australian reptiles. State field guides for reptiles are more of a mixed bag with respect to the groups covered and how up-to-date (or more to the point out of date) they are, and only New South Wales and Queensland have relatively recent and complete treatments of their reptile fauna. Regional field guides have started to appear in more recent years. These are generally well illustrated and contain detailed localized information on the distribution and habitat preferences at a level generally not available in the broader guides – the pick of these are Bush et al.'s 2007 'Reptiles and Frogs in the Bush : Southwestern Australia' and Swan and Watharow's 2005 'Snakes, Lizards and Frogs of the Victorian Mallee'.

However, books dealing primarily with the biology of Australian reptiles are far fewer. Allen Greer produced two landmark volumes, 'The Biology and Evolution of Australian Lizards' in 1989 and 'The Biology and Evolution of Australian Snakes' in 1997, which presented the biology of Australian lizards and snakes in a primarily evolutionary context. Around the same period Rick Shine produced 'Australian Snakes: a Natural History' in 1991, a book aimed providing an "insight into the biology and life history of Australian snakes". In combination, the treatises on snakes by Greer and Shine complemented each other, and provided Australian (and world) herpetologists with a broad synthesis of available knowledge of Australian snakes. But a complementary volume to Greer's lizard book concentrating on the natural history of Australian lizards was missing.

This niche has been competently filled with the publication of Steve Wilson's 'Australian Lizards: A Natural History'. The book starts with 'Meet the Lizards', a general introduction into the diversity of the families of Australian lizards and the features of morphology and behaviour peculiar to each, and then progresses through chapters each dealing with aspects of lizard biology. Collectively, these chapters contain the single greatest compilation of images of lizards 'doing something', a refreshing departure from the classic portrait shots used in guides. One page vignettes dealing with a topic of particular interest appear within the individual chapters, detailing what are effectively stories within a story, such as the inset on the adaptions that allow some geckos to defy gravity and climb apparently smooth surfaces.

Steve Wilson is already established as one of, if not the, premier reptile photographers in Australia, with an impressive track record of photographs published in the Australian herpetological literature and popular journals.

The text in field guides (he is an author on several) is, by necessity of print space, abrupt and impassionate in style. But here, in this latest production, he has been given the opportunity to write in a style that presents information in a more engaging way to the reader, something far more difficult than telegraphic writing for a guide, and has maintained this throughout – for me this is the great achievement of this book.

I have no intention of going through the text in nit-picking detail and listing every minor error for the world to behold, as done recently on social media by a few pretentious individuals when Cogger's Reptiles and Amphibians of Australia became available. Rather, I give Steve Wilson the full credit due for taking on a not-inconsiderable task in producing a thoroughly readable book of nearly 200 pages and bringing it to completion – the kudos due rest solely on his increasingly balding head, and he has just cause to be proud of his latest offering.

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NOTES TO CONTRIBUTORS

Herpetofauna publishes articles on any aspect of reptiles and amphibians. Articles are invited from interested authors particularly non-professional herpetologists and keepers. Priority is given to articles reporting field work, observations in the field and captive husbandry and breeding.

All material must be original and must not have been published elsewhere.

PUBLICATION POLICY

Authors are responsible for the accuracy of the information presented in any submitted article. Current taxonomic combinations should be used unless the article is itself of a taxonomic nature proposing new combinations or describing new species.

Original illustrations will be returned to the author, if requested, after publication.

SUBMISSION OF MANUSCRIPT

Two copies of the article (including any illustrations) should be submitted. Typewrite or handwrite (neatly) your manuscript in double spacing with a 25mm free margin all round on A4 size paper. Number the pages. Number the illustrations as Figure 1 etc., Table 1 etc., or Map 1 etc., and include a caption with each one. Either underline or italicise scientific names. Use each scientific name in full the first time, (eg *Delma australis*), subsequently it can be shortened (*D. australis*). Include a common name for each species.

The metric system should be used for measurements.

Place the authors name and address under the title.

Latitude and longitude of any localities mentioned should be indicated.

Use the Concise Oxford Dictionary for spelling checks.

Photographs – High resolution digital, black and white prints or colour slides are acceptable.

Use a recent issue of Herpetofauna as a style guide.

Manuscripts may be submitted to the editor electronically, via email (gshea@mail.usyd.edu.au) or on CD. Manuscripts submitted electronically must be in Word format, with photographs as separate jpg or tif files.

Articles should not exceed 12 typed double spaced pages in length, including any illustrations.

REFERENCES

Any references made to other published material must be cited in the text, giving the author, year of publication and the page numbers if necessary. At the end of the article a full reference list should be given in alphabetical order. (See this journal).

Manuscripts will be reviewed by up to three referees and acceptance will be decided by an editorial committee. Minor changes suggested by the referees will be incorporated into the article and proofs sent to the senior author for approval.

Significant changes will require the article to be revised and a fresh manuscript submitted.

REPRINTS

The senior author will receive a PDF copy of their article.

Tan-backed Rock Skink (*Liopholis montana*) from Kosciuszko National Park. (Photo: M. Schulz). See paper on the habitat of this species on p. 15.

Gully Skink (*Saproscincus spectabilis*) from Stanwell Park. (Photo: G. Daly). See paper on this range extension on p. 41.